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THE LATE MR. G. E. STREET, R.A.

In our SUPPLEMENT, No. 318, we gave a notice of the leading events of Mr. Street's life. We now give an engraving, and the following remarks from the *Illustrated London News:*

The funeral of this distinguished architect, in Westminster Abbey, was attended, with every sign of personal esteem and of regret for his death, by many of his professional brethren, and by personages of social or official rank. Mr. George Edmund Street, whose portrait is now presented, was born at Woodford, Essex, in 1824, and educated at the Collegiate School, Camberwell. His architectural studies were begun under Mr. Owen Carter, at Winchester, and completed under the late Sir George Gilbert Scott, with whom he remained five years. Like his master, Mr. Street adopted the Gothic style in the buildings he designed, and the numerous essays and lectures which he has written upon architecture have all been directed to illustrate the history and principles and promote the progress of that style. His principal literary efforts are "The Brick and Marble Architecture of North Italy in the Middle Ages," 1855; and "Some Account of Gothic Architecture in Spain," 1865. Mr. Street has for many years been largely engaged in the work of erecting and restoring churches and other ecclesiastical buildings all over the country. To mention only the most prominent among his architectural works, he was the architect of the Cuddesden Theological College, of the new chapel and school rooms of Uppingham College, and of new churches at Bournemouth, Garden Street, Westminster; St. Philip and St. James's, Oxford; St. John's, Torquay; All Saints', Clifton; St. Saviour's, Eastbourne, St. Margaret's, Liverpool; and St. Mary Magdalen, Paddington. Among his restorations may be noticed the churches of Eccleshall, Wantage, Uffington, in Berks, and Stone, in Kent, and Jesus College Chapel, Oxford. He was also the architect of the Earl of Crawford and Balcarres' house at Dunecht. Perhaps his most considerable work in church building was the erection of the nave of Bristol Cathedral in the Early English style. He was engaged upon the restoration of the nave and building of a new choir in Christ Church Cathedral, Dublin, and on building a new synod-house in connection with the Cathedral for the Irish Church. But in London Mr. Street's reputation will mainly rest upon the Royal Courts of Justice in the Strand, now approaching completion. He was appointed architect for this gigantic undertaking in 1868, after a competition in which the most famous architects of the day, including Sir Gilbert Scott and Mr. E. M. Barry, took part. Although a great deal still requires to be done before the interior of the building is finished, the outer shell is fairly complete, and the public are able to judge of the imposing effect which the New Law Courts will present as they are approached from the Strand. Mr. Street was appointed in 1850 diocesan architect to the diocese of Oxford, and he subsequently filled similar posts in the dioceses of York, Ripon, and Winchester. He was a Fellow of the Institute of Architects, of which he has been Vice-President, and a Fellow of the Society of Antiquaries and of other societies. In 1866 he was elected an Associate of the Royal Academy, and was advanced to be a Royal Academician on June 29, 1871. He was also a member of the Imperial and Royal Academy of the Fine Arts at Vienna and a Knight of the Legion of Honor.

THE LATE MR. GEORGE EDMUND STREET, R.A., ARCHITECT.

In the *Gazetta Chemica Italiano*, D. Vitali says there action discovered by Schoenbein in researches on blood stains is preferable to any other. A blue coloration is produced by a mixture of oil of turpentine and alcoholic tincture of the resin of guaiacum on the addition of a little blood or a very dilute solution of hæmoglobin.

ENGLISH CATHEDRALS.*

From the earliest ages of man, and in all parts of the world, religion and art have ever worked together. We see this in the heathen temples of ancient Greece and Rome, in Egypt, India, and Assyria, but it is to the Christian era we must turn to find the highest efforts of man, and where can we find these more gloriously exemplified than in the stately grandeur, truth, and beauty of our English cathedrals? It is true it was in the so-called "dark ages" that these were built, and yet we dare to speak of the enlightenment of this nineteenth century! Would that our faith were as strong now as then. Then should we see our bishops and nobles—aye, and not only them, but our rich and poor alike—all striving to emulate the piety of our forefathers, spending their incomes and making real sacrifices in order to beautify God's sanctuaries. Then should we no longer hear the question asked, "What is the least sum we can build our church for?" as alas! we so often do. In this "enlightened age" men are prone to offer to God of their abundance that which costs them *nothing*. In the "dark ages" they often gave themselves and all they possessed. How much of the wealth thus bestowed was seized by the licentious Henry VIII. under the pretext of "reform" it is painful to contemplate. Three centuries of neglect following the reckless havoc and destruction of Puritan times, with all their sacrilegious greed and plunder, have done much to mar the beauty, not only of our cathedrals, but of nearly every church in the kingdom; yet the Catholic revival has done much to bring back very many of them to something like their former dignity. Much of the spirit of the good old times is returning to us. In not a few places, and by not a few persons, genuine sacrifices *are* being made, and seeing what has been already accomplished, we may look hopefully toward the future of ecclesiastical art in England.

LONDON—ST. PAUL'S.

In such a place as this I can hardly commence better than with a few views of our own cathedral. Whatever we may think of its architecture, we must all appreciate the noble work that is happily being done here. I suppose most present will agree with me that for ecclesiastical buildings at least nothing can compare with the grace and beauty of Gothic art. There seems even something appropriate in the very term "Gothic," a name first given in derision and scorn, as meaning rude and barbarous, so like the term "Christian," first given to the disciples of our Blessed Lord by the heathens of Antioch*—both given as terms of reproach—both have come to be gloried in as representing what is pure and true and noble. Of all our episcopal sees, this of London † founded by Lucius, the first Christain King of Britain, about the year 185, is probably the oldest, though Llandaff is said to have been founded in the same year. The earliest building of which we have any record was that founded by St. Augustine, and built upon the foundations of an old temple of Diana (610), burnt and rebuilt, and burnt again from time to time, till what we generally understand by "Old St. Paul's" was built with great magnificence between the years 1086 and 1310. This was the largest in all England, and its spire the loftiest in Europe (534 feet). Its history from this time is again a series of fires and rebuilding, until its total destruction in 1666. The present building was commenced in 1675 and completed 1710; the area, 59,700 feet, is exceeded by York Minster alone of all our cathedrals, the latter occupying 63,800 feet.

The history of Old St. Paul's is full of interest, and those who have not read Dr. Sparrow Simpson's works would do well to do so, and some may thereby be led to make a still further study of its history.

* From a paper lately read before the St. Paul's Ecclesiological Society by Hugh Roumieu Gough, F R.I.B A.

* Acts xi. 26; Tacitus (Annal. 15), 24, Quos vulgus Christianos apellabat.

† In one of the earliest of the Western Councils, that of Arles in 314, we meet with the names of three British bishops—Eborius of York, Restitutus of London, and Adelphius of Lincoln.

EUROPEAN LIFE STATISTICS.

According to the statistical annual of the Russian empire, the population of Russia increases more rapidly than that of any other European State, except Holland and Denmark. It doubles itself in fifty-eight years. The period in other countries is as follows: Denmark, 56; Holland, 57; Germany, 68; Austria, 95; Switzerland, 99; Italy, 141; France, 165. The births per 1,000 inhabitants are: in Russia, 49; in Germany, 43; in France, 26. The death rate is higher in Russia—37 per 1,000—than in any European country excepting Hungary. The mortality is greatest among children. The death rate of infants of one year old is: in Russia, 1 in 4; in France, 1 in 5; in Prussia, 1 in 6; and in England, 1 in 7. The most remarkable contrast between Russia and the rest of Europe is the comparative absence of illegitimacy. The rate per 1,000 of illegitimate births, which in England is 61, in Italy 66, in France 73, in Germany 88, in Sweden 96, in Denmark 110, and in Austria 124, is in Russia only 30.

The first electric railroad in Upper Silesia is about to be opened. It was built by Siemens and Halske, of Berlin, for the Donnersmarckhutte Company to supersede their ordinary colliery horse railroad. The current is conveyed on ropes supported on poles in the same way as that for the railroad at Paris. Small contact carriages run on the wires, and from these carriages wires conduct the current to the motor. The speed is very moderate, not exceeding eight miles an hour.

ON COMPRESSED AIR.*

By MR. W. H. MASSEY.

THE writer does not profess to suggest anything new in the "notes" which he now presents, and he wishes it to be clearly understood that his observations are offered to those who, whether from lack of opportunity or want of inclination, have not as yet paid very much attention to a subject which is really as interesting as it is important.

Every candid person will admit that, instead of trying to master compressed air, engineers generally would rather avoid it, because of the difficult calculations which a thorough investigation of such a complicated question entails, and it is the writer's object, in this short paper, to point out that it is possible to learn something, and to get hold of simple but sound ideas about "air," without going very deeply into figures; and he hopes that some of the hints here given may be of service even to those who have studied the question attentively. Men who know all the formulæ relating to compression and expansion, and who seem to write very learnedly about the thermodynamic relations, often trip quite helplessly over certain points which, it will be seen, present no real difficulty when the subject is approached in the manner indicated in these "notes." It is a subject that requires much thought, but when once the main principle has been grasped, one cannot help turning with pleasure to scientific text-books, where a full explanation of the various laws is given. Maxwell's "Theory of Heat" is a very cheap and most useful little work; the first part of Clausius' "Mechanical Theory of Heat" may be read with advantage, and much valuable information will be found in some of Clifford's "Lectures and Essays," and also in Professor Crookes' papers on "Radiant Matter." So-called manuals (notably Clark's) should be avoided, because such books, being often compiled by men who know very little of the matter in hand, are too apt to mislead those who refer to them for instruction.

Dry air being merely a mechanical mixture of two gases—which at ordinary temperatures and pressure are so far from their liquefying point that they are called permanent gases—may, for all *practical* purposes, be considered as a perfect gas, and be said to obey the same laws. A gas near its liquefying point is called a vapor; and we may notice in passing, that difference between vapor and gas is one of condition, rather than of composition.

Most persons remember the old experiment with an air-balloon, which being only partially filled swells up if held before the fire or if placed under the bell of an air-pump. The air in the balloon expands in the first case because it is heated, and in the second case because the outside pressure is reduced as the air is exhausted from the bell; but a moment's consideration will show that this is no explanation at all, unless we understand clearly what heat and pressure are.

Heat was for a long time supposed to be a special substance which could be taken up by, or squeezed out of a body; and the temperature of a body was thought to depend upon the amount of this heat substance present in it. The fact that heat did not increase the weight of such body was a great stumbling-block, and many ingenious attempts were made to get over it, though none could be considered satisfactory. Heat was said to assume various forms, and even to hide itself, as the old term "latent heat" may remind us. We still speak of latent heat as being the amount of heat taken up by a body when changing its form from solid to liquid, or from liquid to vapor and gas, while the temperature remains constant. The heat in this case is hidden, however, but has disappeared in the shape of work, which will reappear as heat whenever the body returns to its original state. This is not the only old term which has been retained, for it is still usual to speak of the "capacity for heat" of various bodies, as if heat were even yet supposed to be a substance. But it is necessary to get such ideas out of one's head, and, in the consideration of our present question, simply to look upon heat as being what Locke called "a very brisk agitation of the insensible parts of an object;" and as the dynamic theory of heat is now so well established, the writer can only refer those who wish to satisfy themselves on this point to Professor Tyndall's "Heat a Mode of Motion," in which work the whole subject is treated and explained in most popular language. When speaking then of the heat in a gas, such as air, we mean the motion of the minute particles, or molecules, of which it is composed; and temperature might be taken to mean a measure, in a way, of the rate of which the molecules of a gas are moving. A rise in temperature denotes an increase in speed, and a fall indicates that the particles are not moving so fast; but it must be remembered that the heat, or energy of molecular motion, is as the square of the speed.

But what is pressure?

More than one hundred and fifty years ago, Daniel Bernouilli suggested that the pressure of a gas might be due to the striking of its particles on the sides of the vessel containing it; and this is part of the great molecular theory of the present day; a theory which all our eminent thinkers and mathematicians have, in some way or another, helped to develop. A hypothesis it is no longer, but an experimental fact, which, if understood clearly, explains everything that may arise in the study of compressed air. Maxwell says: "When we have acquired the notion of matter in motion, and know what is meant by the energy of that motion, we are unable to conceive that any addition to our knowledge could explain the energy of motion, or give us a more perfect knowledge of it than we have already." And the writer would submit that whoever can see the truth of this remark has already learned a good deal about air compressing.

Returning now to the experiment with the air-balloon, it is clear that warming the air increases the energy of molecular vibration, which will cause an increase of pressure if the volume is kept constant, or an increase in volume while the pressure is kept constant; as it is in this case, if the resistance of the elastic envelope be neglected. Under the bell of an air-pump, the balance of pressure is upset as soon as any of the air is drawn out, and the air within the balloon will expand, by virtue of its intrinsic energy, until equilibrium is restored.

It would be well to consider what is called the first law of gases, viz., that while temperature is constant the pressure varies inversely as the volume, to see how the molecular theory helps us in practice; and for this let us take the case of the air-cylinder of a compressor, full of air at atmospheric pressure, and just starting to compress. If the temperature is kept constant during compression, it will be found that the pressure increases as the volume is being reduced; so that at half-stroke we have twice the pressure, and at three-quarter stroke—when there is only one-fourth of the original volume—four times the original pressure; which (being that of the atmosphere, or say 14·7 lb. per square inch) gives us four atmospheres' absolute pressure, or three atmospheres—about 44 lb. per square inch on the pressure gauge—above the atmospheric line given on an indicator card. Assuming that the air is delivered at this pressure, and neglecting clearances (as is done in Fig. 1),* we shall, when the piston reaches the end of the stroke, have got rid of a quarter of a cylinderful of air, at four times the pressure at which the air entered it.

Why, under these conditions of isothermal compression, does the pressure vary according to this law?

Let us suppose that, before the piston began to move, we had only one molecule of air in the cylinder, and that the speed of this molecule did not vary during the experiment, but was kept constant (no matter how for the present), whether the piston and end of cylinder were far apart or close together; the molecule simply flying backward and forward between them all the time, along the same straight line. Now, when the piston has moved through half its stroke, the distance between its face and that of the cylinder end is only half the original distance, so that in a given time the molecule will hit each of these surfaces twice as often as it did before, and consequently the pressure will be doubled. When the piston arrives at ¾ in. stroke, the distance separating it from the end of cylinder is now only one-fourth of the original distance, and the number of hits made by the molecule will be four times as great as formerly, and the pressure, therefore, will be four times what it was originally. Now this is just as true for millions of molecules flying about in all directions—in a vessel of any shape—as it is for the molecule we have been considering. Take the case of a cubic foot of air (in a cube) compressed isothermally to half its original dimensions; the molecules have now only half as far to travel between the faces of the cube, and as there is only one-fourth of the original surface, there must be four times the number of molecules on a given area; that is eight times as many hits as formerly on that unit of surface, in a given time. The pressure of the air will have been increased eightfold, while the capacity of the cube has been reduced to one-eighth. The pressure of a gas is always in direct proportion to its density, and both pressure and density vary inversely as the volume, supposing the temperature be kept constant. At constant pressure the density varies inversely as the volume which now varies as the absolute temperature, and it will be seen that the whole question is one of numbers, weights, and speeds; and although in some cases the mathematical investigations are long and difficult, no new mechanical principles are involved; so that we may deal with these imponderable molecules very much in the same way as we do with bodies that we can handle. From the weight of a gas the velocity of its molecules can be easily calculated for any pressure. Thus, a cubic foot of air at atmospheric pressure weighs about one-thirteenth of a pound, and the pressure of, say, 14¾ lb per square inch, or nearly one ton per square foot on each side of the cube, due to the collisions of molecules against it, is represented by $\frac{m\,v^2}{3}$, two-thirds of the kinetic energy,† from which v is found to be nearly twenty miles per minute.

The first law of gases may be formulated thus:

$$p\,v = \text{constant},$$

where p = pressure (in our case 1 atmosphere), and
v = volume (" " cylinderful);

and from this equation we can draw the isothermal curve in the accompanying sketch:

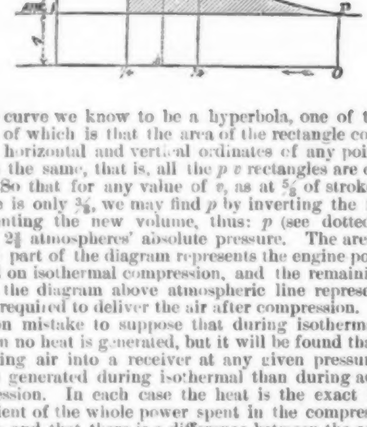

Fig. 1.

This curve we know to be a hyperbola, one of the properties of which is that the area of the rectangle contained by the horizontal and vertical ordinates of any point p is always the same, that is, all the $p\,v$ rectangles are equal in area. So that for any value of v, as at ⅝ of stroke where volume is only ⅜, we may find p by inverting the fraction representing the new volume, thus: p (see dotted lines) $= \frac{8}{3} = 2\frac{2}{3}$ atmospheres' absolute pressure. The area of the shaded part of the diagram represents the engine power expended on isothermal compression, and the remaining portion of the diagram above atmospheric line represents the power required to deliver the air after compression. It is a common mistake to suppose that during isothermal compression no heat is generated, but it will be found that when delivering air into a receiver at any given pressure more heat is generated during isothermal than during adiabatic compression. In each case the heat is the exact thermal equivalent of the whole power spent in the compression of the air, and that there is a difference between the compression areas of the two diagrams may be easily seen. Isothermal compression can only be carried out when the heat due to compression is taken off as quickly as it is generated. If the air be compressed very slowly the heat will disappear by radiation, but if compressed too quickly for the heat to get away in this manner, special arrangements must be made to prevent a rise in temperature during compression.

Supposing, however, that no attempt whatever is made to keep the air cool and that the air is to be compressed in a cylinder which will neither take up any of the heat of itself, nor allow any to pass out of the air, while it is being compressed; this would be a case of adiabatic compression, and we should find that, when the volume had been reduced to one-half, the pressure would not be double only, as in the isothermal case, but more than double, because of the heat generated during compression being still in the air; or, what comes to the same thing, when any given pressure is reached there would be a greater volume of air, owing to the heat in it, than had been found when compression up to that same pressure had been isothermal. In making a diagram to show how the pressure varies in such a case, we must not only take into account the reduction of volume, but also the effect of the heat generated while that reduction is being made. The molecular theory helps us to understand why heat must be generated during both kinds of compression, for as soon as the piston begins to move it increases the energy of molecular vibration in the air contained by the cylinder. Not only is the number of hits in a given time greater, because the space to be traveled by the molecules has been reduced, but their velocity is higher than it was (the temperature is raised), and the pressure is consequently greater than would be due to a mere reduction of volume. It is impossible to compress a perfectly frictionless gas without generating heat, and in the case of adiabatic compression this heat remains in the gas while the operation is being carried on; while in the case of isothermal compression this heat is taken off at once. The effect of a piston's motion was very clearly explained in a class lecture to the Worcester cadets in November, 1877, by Mr. Macfarlane Gray, who has courteously furnished the following extracts:

"If the pressure of a gas or vapor be the reaction of the change of momentum of the particles hitting against and rebounding from the sides of the vessel containing it, what will be the effect upon the particles when the resisting surface does not stand still? A perfectly elastic particle will rebound from the surface at the same speed at which it hits it. Observe, I do not say that the particle has the same actual velocity as before, but that its velocity of approach to the surface is equal to its velocity of leaving the surface. That is to say, its velocity with respect to the body struck is the same before and after impact; but the motion is first toward the body and then away from it.

"In the steam engine the piston is moving away from the particles of the vapor, and if the initial velocity of the particles be, say, v feet per second, and the speed of the piston be, say, u feet per second, then the velocity of approach to the moving surface will be $v - u$, and the velocity of leaving the surface will also be $v - u$; so that the actual velocity of the rebounding particles expressed in relation to the stationary cylinder, will be $v - 2\,u$. Every time the particle hits a piston moving away from it, the actual velocity of the particle is diminished by $2\,u$.

"Conversely, if the operation be one of compression instead of expansion, the velocity of the particle will be increased by $2\,u$ at each hit, because the piston is then moving to meet it; and if a gas were really fully described when stated to be merely elastic particles in agitation in a rigid vessel, we would be able to tell at what rate the pressure and the temperature increased as the volume is diminished by compression. But there is a slight difference between the actual change as determined by experiment, and the change due to the mere to-and-fro motion of the particles or molecules as found by calculation; to account for which there is a generally received theory that the molecules being composed of atoms which have motions of their own, in relation to the molecules themselves, some work is required for producing that motion. This is called the 'internal work,' and is supposed to bear a constant ratio to the whole energy of a gas."

A simple way of making a diagram of adiabatic compression is to draw the isothermal curve first (the fine line in next figure being the same as in Fig. 1), and then add to it, at various pressures, the extra volume due to the heat which has been generated while compressing up to that point. This extra volume can be found by taking the natural number which corresponds to two-sevenths of the logarithm of the absolute pressure; which gives the ratio of volume after adiabatic compression, to volume due to isothermal compression. Thus at 2, 3, and 4 atmospheres absolute the

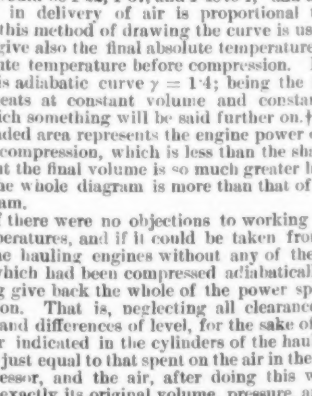

Fig. 2.

volumes would be 1·22, 1·37, and 1·48 to 1,* and as the power expended in delivery of air is proportional to the final volumes, this method of drawing the curve is useful. These numbers give also the final absolute temperature in terms of the absolute temperature before compression. In the equation to this adiabatic curve $\gamma = 1{\cdot}4$; being the ratio of the specific heats at constant volume and constant pressure, about which something will be said further on.†

The shaded area represents the engine power expended in adiabatic compression, which is less than the shaded part of Fig. 1; but the final volume is so much greater here that the area of the whole diagram is more than that of the isothermal diagram.

Now, if there were no objections to working with air at high temperatures, and if it could be taken from compressors to the hauling engines without any of the heat being lost, air which had been compressed adiabatically would in expanding give back the whole of the power spent in it in compression. That is, neglecting all clearances, friction, leakages, and differences of level, for the sake of simplicity, the power indicated in the cylinders of the hauling engines would be just equal to that spent on the air in the air cylinder of compressor, and the air, after doing this work, would escape at exactly its original volume, pressure, and temperature before compression. Supposing, for argument's sake, that it were possible to work thus without any loss of heat in the air, we find that even then the high percentages of useful effect which we are sometimes told ought to be got (in some cases as much as 80 per cent. has been spoken of), cannot be obtained. The power indicated in the air cylinder of compressor is never likely to be much more than 85 per cent. of the indicated power of the steam cylinder, and, as the actual efficiency of any hauling engine will never very much exceed 70 per cent., it is apparent that about 60 per cent. is all that it is possible to obtain, even if nothing is lost in the air. It being well-nigh impossible to prevent loss of heat by radiation, while the air is on its way from com

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* Read at a meeting of the South Wales Institute of Engineers, held in Cardiff, January 30, 1881

* The figures in this paper were prepared from hand sketches, and are intended only to act as rough guides to the eye.

† The work accumulated in a moving body being expressed by $\frac{m\,v^2}{2}$.

* Log. of 2 is 0·30103, { which multiplied by 2/7 } = 0·086 { which is log. of } 1·22
" 3 " 0·47712 " " = 0·136 " 1·37
" 4 " 0·60206 " " = 0·172 " 1·48

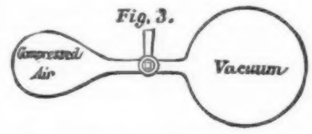
† The value of γ, as determined by some old measurements of the velocity of sound, = 1·408, which is generally taken as being the ratio of the elasticities of air.

pressor to hauling engines, isothermal compression must prove the more economical; because, after it, the volume of compressed air is the same on reaching the hauling engines as when leaving the air cylinder of the compressor; whereas after adiabatic compression the larger volume gradually gets less by loss of heat, till it is only equal to that delivered after isothermal compression. So the great loss attending adiabatic working is due to having expended a large power in the delivery of a quantity of air, which although compressed rather more economically, might have been delivered with much less work if a little more power had been spent in compression.

Air used without expansion does no work. When worked with full expansion, air which has been compressed isothermally, or which has been allowed to cool down at constant pressure after abiabatic compression, does not give back any of the power spent on it in compression, because the heat generated during compression has been lost in each case But the air will do work by virtue of its original store of energy, which is rendered available after compression, and the adiabatic curve showing how much expansion can be got from a quarter of a cylinder of air at four atmospheres' absolute pressure, is given in Fig. 2 (see dot and dash line), and the final volume will, when the pressure reaches that of the atmosphere, be much less than the original volume before compression, by reason of the heat which has now disappeared in the shape of work; the energy remaining in the air being less than the original amount by just that quantity of work. The writer would like to make it clear, if possible, that one pound of air at four atmospheres absolute pressure—or even at forty atmospheres—has no more energy in it than one pound of air at the ordinary atmospheric pressure—all at the same temperature, of course —for if these respective pressure-volumes of air be expanded till the absolute zero of temperature is reached, the areas included by the adiabatic expansion curves will in each case be equal to $\frac{p\,v}{\gamma - 1}$, or about $2\frac{1}{2}$ times the rectangle representing the pressure and volume of the air before expansion. The energy of a gas is a function of the temperature, and is entirely independent of its volume; but as the work done during adiabatic expansion is the mechanical equivalent of the energy which the gas has parted with, the area of that portion of the work diagram will always be equal to $2\frac{1}{2}$ times the loss of pressure-volume.

It has been proved, by an experiment something like the following, that a gas may expand without doing external work.

Fig. 3.



One vessel filled with compressed air is connected by a pipe and cock with another vessel from which all air has been exhausted; and on opening the cock the air expands and fills both vessels, but there is no loss of heat. The temperature falls in one vessel and rises slightly in the other, but the mean temperature is the same as before,* as no external work has been done. Suppose the smaller vessel in Fig 3 to be just one-third of the capacity of the larger one, and to be filled with one pound of air at four atmospheres' absolute pressure, we shall find, after opening the cock, that we have now four times the volume at ordinary atmospheric pressure. No external work has been done, and there is consequently no loss of heat, so that our one pound of air at this reduced pressure, but at same temperature, has as much energy in it now as when at four times the pressure. Our molecular theory helps us here also; the velocity of the particles is the same in this case before and after expansion, because no work has been done; there has been no loss of energy; the molecules have given up none of their motion; but the new pressure and density are only one-fourth, being in inverse ratio to the volume. A gas parts with its heat by communicating motion of some sort to something or another; its energy is given up as its molecules come to a comparative state of rest, while their motion is being taken up by something else.

In ordinary work it is not practicable to use air in such a way as to get back any of the power expended on it, and as the work it can do of itself by expansion is never equal to the power spent, it is clear that the useful effect can never be what we supposed above, that is, about 60 per cent. At four atmospheres the loss in the operation of compression and expansion is not less than 18 or 20 per cent., leaving, say, 80 per cent. of useful effect to multiply into the percentages we calculated before, which would bring the possible useful percentage down to about 50 per cent. Ordinary compressing and hauling engines in this country are giving off about half this, and, all things considered, are doing well at that; simple and durable machinery being more sought after than complications about the air cylinders that might save a little of the power now wasted, and effect a slight economy in fuel, which is generally used at our collieries as if it really cost nothing; and although improvements certainly, they would hardly be worth what would have to be paid for them. Where fuel is dear the cost of producing the compressing power can be greatly reduced, by using steam at a high pressure and working it expansively. All questions relating to the loss of power in the air, and to the extravagant use of coal, should, however, be dealt with separately.

When speaking of the low percentages of useful effect obtained if compressed air is employed for working hauling engines in our collieries, it would be well to remember that the useful work, in actual practice, represents some 25 to 30 per cent. of the indicated horse power of a steam engine placed near a boiler. Suppose a steam hauling engine to be so placed, and to give off 70 per cent. in useful work, of its indicated power, then the ratio of the efficiencies of the two systems would be as 70 is to 25 and 30. In other words, ordinary air engines are doing from 35 to 45 per cent. of what a steam engine would do when working under the very best conditions.

It is not the writer's intention to go into practical details here, but he would now wish to correct a mistake that is sometimes made with regard to clearances in air cylinders of compressors. They cause a loss of power when air is compressed isothermally; and whichever way air is compressed, clearances mean a loss of capacity, and should be avoided. They should be carefully measured before cards are taken from the air cylinders, so that a fair comparison may be made with the actual and the isothermal curves; and if the former turn out to be much better than was expected, their beauty is most probably due to a leaky piston.

Many persons have said that the increase of pressure, due to a difference in levels, is not a gain; but M. Pernolet, a careful French writer, has pointed out that the gain would probably balance the loss of pressure due to friction through the pipes leading to a mine. Neglecting all question of temperature, the gain of pressure, and consequent reduction in volume, may be called a gain, just as in our common language the mechanical advantage obtained by using a lever is called a gain of power. When temperature is taken into account, it seems to the writer that, in deep warm pits, cases may occur where, owing to the gain of pressure and heat, air compressed at the surface would do more work at the bottom of a pit than it would at the top. Attempts have been made, sometimes very successfully, to warm compressed air while expanding, and so put new energy into it, much of which would be returned in the shape of useful work. If a very slow expansion could be carried out, much heat from the mine would be transferred to the air, and come out as work; and it is possible that some method of compounding the cylinders of a hauling engine will prove beneficial.

At all ordinary pressures, and at freezing point, most gases expand $\frac{1}{491}$ of their volume for a rise of 1 deg. Fahr.; and so it may be said that at constant pressure the volume varies as the absolute temperature. The amount of heat required to raise 1 lb. of air one degree, as compared with the quantity needed for raising the same weight of water through an equal range, is called its specific heat, and at atmospheric pressure this is very nearly 0·238. Thus rather more than 4 lb. of air, at constant pressure, may be raised one degree for the same expenditure of heat as for 1 lb. of water—that is, for one heat unit—the mechanical equivalent of which is 772 foot-pounds; and the work done on a gas, or by a gas, may be calculated from the rise in temperature, or from the heat lost. The specific heat at constant volume—which is the true specific heat—is only 0·169, and the ratio of the two specific heats is $\frac{0{\cdot}238}{0{\cdot}169} = 1{\cdot}4$, which is approximately constant for all temperatures and densities. More heat is required to raise the temperature of air at constant pressure than when the volume is kept constant, because in the former case external work is being done, while in the latter the whole of the new energy remains in the gas; and the experiment of allowing a gas to expand into a vacuum may be used to show that, after being heated at constant volume till the pressure is doubled, the gas would lose no heat in expanding to double the volume. It is clear from this that the difference in specific heats is due to external work being done in one case and not in the other, and that a gas expanding at constant temperature absorbs only the amount of heat required for doing external work. The heat required to raise the temperature of a given weight of air one degree, at constant volume, is also shown by this experiment to be the same, no matter what the volume and pressure may be; because the expansion (in a vacuum) to any new volume and pressure is isothermal.

The vacuum here spoken of is a space, usually called empty, but which must be full of some very rare gas or ether, whose molecules will carry the waves of light and heat, as the molecules of a coarser gas, such as air, will in a different manner carry those of sound. Such a luminiferous ether may pervade all space, and if its molecules are but small enough to go through the pores of all known substances—as they undoubtedly are—the molecular theory of gases still holds good, and helps us to see how the vibrations of light and heat are brought to us from the heavenly bodies; a sort of motion, a mere tremor of the ether, which we can detect, and may some day measure very exactly; for quite recently a thermal balance has been constructed which is to be applied to the measurement of stellar heat, and which is so sensitive that it will mark a change of $\frac{1}{50000}$ of a degree Fahr. in temperature. Whatever difficulty there may be in forming an idea of the constitution of this ether, there can be very little doubt that interstellar space is occupied by a substance more uniform than anything we know of. It is capable of transmitting energy, and its radiation acting on our senses affords proof that work is done; while from the heat transmitted to bodies the energy of radiation can be calculated. The enormous store of energy in such an ether is almost beyond our conception. Mr. Macfarlane Gray pointed out, in an interesting paper read before the Physical Society last year, that if ether be a very fine gas, the density of which is only the one-millionth part of the density of ordinary atmospheric air (which weighs 6,000,000 tons per cubic mile), and that if the velocity of the ether molecules be equal to the highest estimate of the speed of light—190,000 miles per second—then the pressure of such an ether gas must be more than six million pounds per square inch. These figures are hardly more startling than some of those we come across in cases of chemical combination of known gases. The energy of 8 lb. of oxygen atoms combining with 1 lb. of hydrogen to form water, is equal to that of 21 tons falling 1,000 feet, and if these gases are made to burn, the flame has a temperature of about 9,000 deg., a heat that scarcely anything can withstand. From the same source, so to speak, we have both fire and water. Faraday once said that "the electric force in a single drop of water was of itself greater than in the electricity of a whole thunderstorm;" and it is impossible to realize what is going on around us continually unless we have some theory of atoms and molecules to assist us in thinking matters out. The air we breathe, and the water which covers nearly three-fourths of our globe, are composed of simple gases; three invisible gases and pure carbon combine to form the bodies of all living things, both animal and vegetable; the very perfumes of flowers are compound substances formed of molecules, and they can all be produced artificially from those hydrocarbons which are changed by heat and light. The mere alteration in the arrangement of the molecules of a simple gas will sometimes make it behave like some new substance; thus ozone absorbs more heat than oxygen, though they are one and the same thing. One of the effects of chemical combination may be seen in the case of nitrous oxide, consisting of the very same atoms of the two gases, nitrogen and oxygen, which, in a state of mechanical mixture, constitute our atmosphere. It is just as transparent to light as ordinary air is, and yet it will absorb more than 1,800 times as much radiant heat as air will.* All these questions have a bearing on the matter we have in hand; and though the writer is not a mere theorist, he believes firmly that it is only by the earnest application of practical minds to subjects which cannot be learnt from ordinary experience, that anything really useful and sound can be developed in connection with compressed air; otherwise it is impossible to separate theoretical difficulties, which are insuperable, from practical difficulties that may perhaps be overcome.

It is no longer the fashion to deride all attempts made to solve questions relating to what cannot be seen and laid hold of with our hands; and, as the study of the molecular theory helps to make clear much of what is hard to understand about heat, light, sound, chemical action, and electricity, the writer of these "notes" hopes that many will be induced to give it serious attention, even if they do not at present see how it can be useful to them. Time spent in this way cannot be said to be wasted; for even if the knowledge acquired is small, it may be enough to prevent our being led away by vague terms, which are too often used to cover the ignorance of those who would make a mystery of what is not after all so difficult to learn thoroughly, if we will but take the trouble. Much careful thought is needed for the study; but there is a strange fascination about the subject which makes all labor in it light enough to be enjoyed as an intellectual treat by even the humblest student.

* In some later experiments, by Joule and Thomson, the thermal effects of free expansion have been more accurately measured, and it is now believed that a very slight cooling does take place. The velocity of agitation of the molecules, to which temperature is due, is not much affected; but on the whole there is enough to suggest that there may be a small force of attraction between the molecules. In the case of a vapor this force is considerable, and the power needed for compression is less than is required for a perfect gas.

* See Tyndall's works.

THE AIR OF STOVE-HEATED ROOMS.

By W. MATTIEU WILLIAMS.

WHATEVER opinions may be formed of the merits of the exhibits at South Kensington, one result is unquestionable—the exhibition itself has done much in directing public attention to the very important subject of economizing fuel and the diminution of smoke. We sorely need some lessons. Our national progress in this direction has been simply contemptible, so far as domestic fireplaces are concerned.

To prove this we need only turn back to the essays of Benjamin Thompson, Count of Rumford, published in London just eighty years ago, and find therein nearly all that the Smoke Abatement Exhibition *ought* to teach us, both in theory and practice—lessons which all our progress since 1802, plus the best exhibits at South Kensington, we have yet to learn.

This small progress in domestic heating is the more remarkable when contrasted with the great strides we have made in the construction and working of engineering and metallurgical furnaces, the most important of which is displayed in the Siemens regenerative furnace. A climax to this contrast is afforded by a speech made by Dr. Siemens himself, in which he defends our domestic barbarisms with all the conservative inconvincibility of a born and bred Englishman, in spite of his German nationality.

The speech to which I refer is reported in the "Journal of the Society of Arts," Dec. 9, 1881, and contains some curious fallacies, probably due to its extemporaneous character; but as they have been quoted and adopted not only in political and literary journals, but also by a magazine of such high scientific standing as *Nature* (see editorial article Jan. 5, p. 219), they are likely to mislead many.

Having already, in my "History of Modern Invention, etc.," and in other places, expressed my great respect for Dr. Siemens and his benefactions to British industry, the spirit in which the following plain-spoken criticism is made will not, I hope, be misunderstood either by the readers of *Knowledge* or by Dr. Siemens himself.

I may further add that I am animated by a deadly hatred of our barbarous practice of wasting precious coal by burning it in iron fire-baskets half buried in holes within brick walls, and under shafts that carry 80 or 90 per cent. of its heat to the clouds; that pollute the atmosphere of our towns, and make all their architecture hideous; that render scientific and efficient ventilation of our houses impossible; that promote rheumatism, neuralgia, chilblains, pulmonary diseases, bronchitis, and all the other "ills that flesh is heir to" when roasted on one side and cold-blasted on the other; that I am so rabid on this subject, that if Dr. Siemens, Sir F. Bramwell, and all others who defend this English abomination, were giant wind-mills in full rotation, I would emulate the valor of my chivalric predecessor, whatever might be the personal consequences.

Dr. Siemens stated that the open fireplace "communicates absolutely no heat to the air of the room, because air, being a perfectly transparent medium, the rays of heat pass clean through it."

Here is an initial mistake. It is true that air which has been artificially deprived of *all* its aqueous vapor is thus completely permeable by heat rays, but such is far from being the case with the water it contains. This absorbs a notable amount even of bright solar rays, and a far greater proportion of the heat rays from a comparatively obscure source, such as the red-hot coals and flame of a common fire. Tyndall has proved that 8 to 10 per cent. of all the heat radiating from such a source as a common fire is absorbed in passing through only 5 feet of air in its ordinary condition, the variation depending upon its degree of saturation with aqueous vapor.

Starting with the erroneous assumption that the rays of heat pass "clean through" the air of the room, Dr. Siemens went on to say that the open fireplace "gives heat only by heating the walls, ceiling, and furniture; and here is the great advantage of the open fire;" and, further, that "if the air in the room were hotter than the walls, condensation would take place on them, and mildew and fermentation of various kinds would be engendered; whereas, if the air were cooler than the walls, the latter must be absolutely dry."

Upon these assumptions, Dr. Siemens condemns steam pipes and stoves, hot-air pipes, and all other methods of directly heating the *air* of apartments, and thereby making it warmer than were the walls, the ceiling, and furniture when the process of warming commenced. It is quite true that stoves, stove pipes, hot-air pipes, steam pipes, etc., do this: they raise the temperature of the air directly by *convection; i. e.*, by warming the film of air in contact with their surfaces, which film, thus heated and expanded, rises toward the ceiling, and, on its way, warms the air around it, and then is followed by other similarly heated ascending films. When we make a hole in the wall, and burn our coals within such cavity, this convection proceeds up the chimney in company with the smoke.

But is Dr. Siemens right in saying that the air of a room, raised by convection above its original temperature, and above that of the walls, deposits any of its moisture on these walls? I have no hesitation in saying very positively that he is clearly and demonstrably wrong; that no such condensation can possibly take place under the circumstances.

Suppose, for illustration sake, that we started with a room of which the air and walls were at the freezing point, 32° F., before artificial heating (any other temperature will do), and, to give Dr. Siemens every advantage, we will further suppose that the air was fully saturated with aqueous vapor,

i. e., just in the condition at which some of its water might be condensed. Such condensation, however, can only take place by cooling the air below 32°, and unless the walls or ceiling or furniture is capable of doing this they cannot receive any moisture due to such condensation, or, in other words, they must fall below 32° in order to obtain it by cooling the film in contact with them. Of course Dr. Siemens will not assert that the stoves or steam-pipes (inclosing the steam, of course), or the hot air or hot water pipes, will *lower* the absolute temperature of the walls by heating the air in the room.

But if the air is heated more rapidly than are the walls, etc., the *relative* temperature of these will be lower. Will condensation of moisture *then* follow, as Dr. Siemens affirms? Let us suppose that the air of the room is raised from 30° to 50° *by convection purely;* reference to tables based on the researches of Regnault, shows that at 32° the quantity of vapor required to saturate the air is sufficient to support a column of 0·182 inch of mercury, while at 50° it amounts to 0·361, or nearly double. Thus the air, instead of being in a condition of giving away its moisture to the walls, has become thirsty, or in a condition to *take moisture away from them* if they are at all damp. This is the case whether the walls remain at 32° or are raised to any higher temperature short of that of the air.

Thus, the action of close stoves and of hot surfaces or pipes of any kind is exactly the opposite of that attributed to them by Dr. Siemens. They dry the air, they dry the walls, they dry the ceiling, they dry the furniture and everything else in the house.

In *our* climate, especially in the infamous jerry-built houses of suburban London, this is a great advantage. Dr. Siemens states his American experience, and denounces such heating by convection because the close stoves *there* made him uncomfortable. This was due to the fact that the winter atmosphere of the United States is very dry, even when at zero. But air, when raised from 0° to 60°, acquires about twelve times its original capacity for water. The air thus simply heated is desiccated, and it desiccates everything in contact with it, especially the human body. The lank and shriveled aspect of the typical Yankee is, I believe, due to this. He is a desiccated Englishman, and we should all grow like him if our climate were as dry as his.* The great fires that devastate the cities of the United States appear to me to be due to this general desiccation of all building materials, rendering them readily inflammable and difficult of extinction.

When an undesiccated Englishman, or a German endowed with a wholesome John Bull rotundity, is exposed to this superdried air, he is subjected to an amount of bodily evaporation that must be perceptible and unpleasant. The disagreeable sensations experienced by Dr. Siemens in the stove-heated railway cars, etc., were probably due to this.

An English house, enveloped in a foggy atmosphere, and incased in damp surroundings, especially requires stove-heating, and the most inveterate worshipers of our national domestic fetish, the open grate, invariably prefer a stove or hot-pipe-heated room, when they are unconscious of the source of heat, and their prejudice hoodwinked. I have observed this continually, and have often been amused at the inconsistency thus displayed. For example, one evening I had a warm contest with a lady, who repeated the usual praises of the cheerful blaze, etc., etc. On calling afterwards, on a bitter snowy morning, I found her and her daughters sitting at work in the billiard-room, and asked them why. "Because it was so warm and comfortable." This room was heated by an eight inch steam-pipe, running around and under the table, to prevent the undue cooling of the India-rubber cushions, and thus the room was warmed from the middle, and equally and moderately throughout. The large reception room, with a blazing fire, was scorching on one side, and freezing on the other, at that time in the morning.

The permeability of ill-constructed iron stoves to poisonous carbonic oxide, which riddles through red-hot iron, is a real evil, but easily obviated by proper lining. The frizzling of particles of organic matters, of which we hear so much, is—if it really does occur—highly advantageous, seeing that it must destroy organic poison-germs. Under some conditions, the warm air of a room *does* deposit moisture on its cooler walls. This happens in churches, concert-rooms, etc., when they are but occasionally used in winter time, and mainly warmed by animal heat, by congregational emanations of breath-vapor, and perspiration—*i. e.*, with warm air supersaturated with vapor. Also, when we have a sudden change from dry, frosty weather to warm and humid. Then our walls may be streaming with condensed water. Such cases were probably in the mind of Dr. Siemens when he spoke; but they are quite different from stove-heating, which increases the vapor capacity of the heated air, without supplying the demand it creates.—*Knowledge.*

THE SERVIA.

THE distance between England and the United States is gradually being annihilated, and the Atlantic passage begins to lose some of its terrors when little more than seven days need be spent in making it. The recently built Cunard steamer Servia reached Queenstown last week after having made what is claimed to be the shortest trip from New York on record. The actual time occupied was seven days seven hours and forty-one minutes, a very remarkable performance, taking into account that the route followed by the Cunard liners is ninety miles longer than that adopted by other steamers, and that easterly winds were encountered for some days. The Servia's feat gives a somewhat striking corroboration to the remarks of Mr. Denny, the well-known Dumbarton shipbuilder, on the dimensions of the future Atlantic steamers, which we published recently. Mr. Denny urged that in order to gain the necessary rigidity, shorter vessels, shorter even than the Servia, would have to be built, the breadth of beam would then be increased, and that would be followed by larger draught; and while the greater draught would give more cargo-carrying capacity, it would at the same time add to the speed of the steamer, because the propeller would be more constantly submerged. The force of these remarks has been signally exemplified by the case of the Servia, for although her length exceeds what Mr. Denny considers the proper limit, it is still far short of that of the City of Rome, which has been looked upon as somewhat her rival, the length of the former steamer being 530 feet, and of the latter 586 feet. At the same time, the breadths of the two vessels are almost exactly the same, the City of Rome being 52 feet 3 inches broad and the Servia 52 feet. But the last-named has a depth of no less than 44 feet 9 inches, while the larger steamer has only 37 feet depth of hold. The performance of the Servia is another leaf added to the laurels of the Clyde shipbuilders, this steamer having been built by Messrs. J. & G. Thomson, and the Cunard Company may be congratulated upon having, through her, maintained their already well-deserved supremacy.

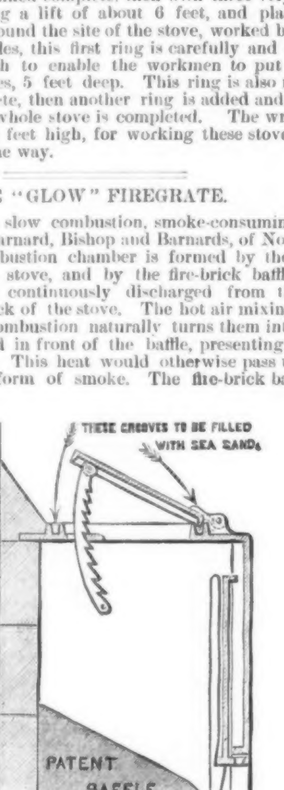
* In each of my three visits to America I lost about thirty pounds in weight, which I recovered within a few months of my return to the "home country" (of English-speaking nations).—ED.

WROUGHT-IRON CHIMNEYS.

AT the Pennsylvania Steel-Works, at Harrisburg, they have a good plan of erecting the casings of fire-brick hot-air stoves and wrought-iron chimneys. Two new blast-furnaces are erecting there, with six Whitwell stoves, 18 feet diameter, 60 feet high. Instead of putting the *bottom* plates of the stove together on the ground, and building the rings up from bottom to top, they commence with the *top* plates and top ring of the stove. They are first erected on the ground and riveted and calked complete, then with three very large screw-jacks having a lift of about 6 feet, and placed at equal distances around the site of the stove, worked by men with winch handles, this first ring is carefully and evenly lifted high enough to enable the workmen to put on the next ring of plates, 5 feet deep. This ring is also riveted and calked complete, then another ring is added and lifted, and so on till the whole stove is completed. The wrought-iron chimney, 175 feet high, for working these stoves, was erected in the same way.

THE "GLOW" FIREGRATE.

WE illustrate a slow combustion, smoke-consuming firegrate of Messrs. Barnard, Bishop and Barnards, of Norwich, England. A combustion chamber is formed by the back and sides of the stove, and by the fire-brick baffle, into which hot air is continuously discharged from the air chamber at the back of the stove. The hot air mixing with the products of combustion naturally turns them into gas, which must ascend in front of the baffle, presenting all its heat to the room. This heat would otherwise pass up the chimney in the form of smoke. The fire-brick baffle is movable, so that at any time it can be replaced or removed for the purpose of sweeping the chimney. This stove meets two great requirements. First, in giving a maximum of heat with the smallest quantity of fuel; and, secondly, in consuming all products of combustion, thereby effectually getting rid of smoke. These desirable objects are attained without sacrificing the pleasant appearance of an open fire, which is a great desideratum.—*Iron.*



FOUNDATIONS.

By WILLIAM C. STREET.

AT a recent meeting of the Civil and Mechanical Engineers' Society, London, the following paper on "Foundations" was read by Mr. William C. Street, A.R.I.B.A.

In bringing this subject forward as a topic of discussion, I would claim that it merits the earnest attention of both engineer and architect. It is often taken as too much a matter of course, and in consequence, some of our greatest efforts in construction are brought to grief, and that by the neglect of what is obviously the first essential of all good building; while on the other hand, sometimes the most creditable and successful part of our work, and what has cost us most thought and care, is hidden from view, and its importance quite unappreciated, especially by those long-necked geese who would be most sapient and loudest in condemnation if anything were to go amiss.

It were almost needless to say that, before dealing with any particular foundation, it would be well to consider and calculate the weight of the wall or the work we are going to place upon it, and also whether it will be a steady weight or one subject to vibration. The weight imposed on the footings of an ordinary London house, say fifty feet high, with four floors all loaded, is perhaps about seven tons per square foot, while in St. Paul's Cathedral, the greatest strain is fourteen tons per square foot. Almost every substance in nature is capable of supporting some other substance or weight, and, given a capacity of sustentation, if ever so little, per square foot, it is a simple sum to determine how many square feet will be required to take in absolute safety the weight transmitted. By distributing the weight over a sufficiently large area, almost any soil may therefore be safely built upon, provided that its conditions are of a permanent character.

This question of constancy is one requiring more than ordinary forethought. Of course there are cases in which no one could foresee what was subsequently to take place. I know, for instance, of two churches in the London district which were threatened with destruction by the construction of railways in their vicinity. One is in the south-eastern or Bermondsey district, and many years ago, during the construction of one of the viaducts carrying the Greenwich Railway, the contractors opened a large extent of deep foundations, which had to be kept clear of water by incessant pumping This, of course, underdrained and contracted or lowered the ground in the locality, and several alarming cracks made their appearance in the building; a great outcry was raised by the parochial authorities, and the railway company was threatened with heavy damages, but by judicious procrastination on the part of their agents, the dispute was deferred until after the completion of the work, when the pumping having ceased, the level of the water in the soil gradually rose to its former height, and the cracks nearly closed again, so that, by aid of neat pointing, the permanent damage was but slight.

In the second case, the church was built with quite adequate and apparently deep enough foundations, but seven or eight years afterward a surburban railway is constructed, passing here in a cutting over twenty feet below them, and only a few yards off In this case the drainage was, of course, permanently lowered, and the eastern end of the church, that nearest the line, showed a decided inclination to part company with the nave. The architect, of course, advised that the right thing to be done was to underpin, to a sufficient depth, to insure permanent stability. This heroic and costly sort of procedure was objected to by the penuriously minded, and one of the churchwardens, a votary of modern science, bethought himself of a cunning worker in metals, who took the matter in hand, and has tied together the ruptured parts, in an economic manner, with iron bands. Up to the present this has sufficed. I only hope that what was the weaker member may not ultimately pull the stronger with it to destruction, and I would sooner have contributed to good masonry underpinning, than to this ingenious artifice.

Also in the case of the destruction of several large shops and houses in the Seven Sisters Road, about two years since, the disaster was, I believe, clearly proved to have been occasioned by the disturbance of the ground, at a dangerous depth close to them, for the formation of a sewer just after they had been erected, and when everything was green and unset. It is, therefore, always wise to carefully consider what possible, if not probable, alterations may take place, changing the condition of the substratum or foundation from that in which it is when you build. I will now proceed to notice several different kinds of foundations, and, so far as I know, the best way of dealing with them.

PEAT FOUNDATIONS.

In some soils, such as peat, it is often practically impossible to carry your walls down to a sufficient depth to meet with a solid base or foundation; and in such cases you have three courses open to you; either to found on a strong concrete floor spread over a sufficient area, or to use piles, or to use cylinders of iron or brick. If the first course is determined on, you should not only carry your floor all over the surface to be occupied by your buildings, and see that it is constructed so as to be thoroughly sound and homogeneous, but take care that the edges extend well beyond the footings of your walls.

I believe that the cracks and settlements in some buildings, with which I was connected as clerk of the works, and constructed on such a foundation, were entirely due to very heavy walls coming close on to the edge of the concrete floor, causing it to buckle and crack, and to settle irregularly as weighted by walls of unequal thickness, etc

Another characteristic of this settlement was the gradual and continued settlement of the heavy corners, and I think the French system of forming a lip on the underside of the edge is a good one, as it tends to keep the substratum within its limits, and makes the concrete floor or foundation into a kind of inverted tray. The material of your foundations cannot be too strong and homogeneous; but with regard to the superstructure, I would prefer a coursed and bonded or articulated construction that would, if necessary, yield slightly at the joints, and accommodate itself without fracture to any slight or unequal settlements during construction. This is the more necessary when the foundation to be got is not of the best.

In the case of some mansions, close to where we now are, they also are floating on peat, and this precarious condition was, I fear, aggravated, by putting in the foundations in small sections, at different times, and with inferior concrete. The consulting engineers who were called in deprecated underpinning, and built a retaining wall of concrete on the eastern side, and made concrete inverts to some of the basement chambers. I am, however, greatly deceived if the buildings have not continued settling since this was done, about May, 1878. The Admiralty buildings at Whitehall are also upon a similar foundation, but are built upon piles, and apparently with great success, for I do not remember having noticed any particular settlement about the building. That the ground in the locality is sufficiently lively I can personally testify, for the passage of a heavy two-wheeled cart would make a room in Whitehall Place, in which I used to work, vibrate so much as to frighten those who were unused to it.

SAND FOUNDATIONS.

In founding work on running sand the utmost care and consideration are needed; I have known a length of wall to be undermined by the pumping out of the sand with the water when putting in the foundations for the next length. The only way in such a case is to make a good concrete floor the entire width of the trench, and put it in as quickly as possible, to seal the sides of the trench as well as you can, and to pump out what water comes in from the level of the top of the concrete, and not from a sump. In the case of dock-walls founded upon running sand, it is also necessary to consider what, if any, will be the effect produced when the pumping operations, necessary during construction, are brought to a termination, and the water allowed to exert a varying pressure on the floor of the dock and the foundations of the walls, in accordance with the variations of tide level outside the dock.

It is open to us all to be very wise after an occurrence has taken place, and the circumstances connected with it suffi-

ciently explain the nature and causes of the accident, while if we had anything to do with the direction we might not have done nearly so well as those upon whom the misfortune or failure fell. Therefore, in indicating in any case, not connected with my own practice, how, in my opinion, the foundations, as seen by the light of others' experience, might be improved in the reconstruction, I do so with all humility, and do not pretend for a moment that I should have foreseen and prevented what really did happen.

In a recent notorious case, the damage to the works did not happen until after their completion, when the water being admitted to and constantly retained in the interior at the level of high water, the pressure of the water downward and outward at low water was such that it forced itself through the sandy floors of the dock, and under and along the line of the lock foundations out into the river, sucking with it such immense quantities of silt or running sand, as to cause a general undermining and ruin of the dock works. There was, of course, a similar varying pressure inwards from the river during the construction of the works, but the dam at the entrance kept this sufficiently far off to prevent ill effects. When, however, this dam was removed and the distance reduced, the effect of similar pressures outward was so much greater that in a few weeks the underground passage was established, and the catastrophe occasioned. It would not perhaps have happened had the pile apron across the mouth of the lock on the inner or dock side been driven to a greater depth and sufficiently close and tight together so as to retard the subterranean flow of water and sand.

Apparently only a very little extra force one way or other was sufficient to turn the balance from safety to danger. The most eminent engineering advice has been taken with regard to the reconstruction, and I am perfectly unacquainted with the measures proposed; but it would appear obvious that in such a case the new lock might be made longer with much advantage, and thereby the distance between the river and the floor of the dock increased; also, that right across the mouth of the lock, at both river and dock end, two rows of either wood or iron-sheet piling should be driven as deep as possible and the sand between them excavated for some depth, and the space filled in with good clay puddle, so as to form two watertight underground walls at each end, and sufficiently remote from each other not to occasion danger. Further, the floor of the dock might be covered with a good thick layer of clay puddle, as is usual when a reservoir is made to hold water for the supply of towns, and I do not know that engineers have any good reason for neglecting this precaution when they build a reservoir to hold water and ships, especially when the natural foundations are well known not to be watertight.

While speaking of the narrow line between safety and danger, and insisting upon always being upon the right side, it is perhaps well to know what can be said upon the other side. The engineer to a Scotch dock not long since was remonstrated with by one of the commissioners with regard to a slight mishap which had occurred to a portion of the work, and he replied that he considered it proved his ability, because he could well have insured safety, and his reputation, if he had made the work cost double the amount it did; but he had been so careful of their interests that he had made a very cheap dock, and with only an insignificant accident. Such reasoning can be carried too far, and as foundations are but a small portion of the expense, while they are the most important so far as stability is concerned, you cannot be too safe there.

With regard to foundations for bridges or piers, on or across sands, the usual plan now is to sink tubes or piles with large disk or screw shoes or feet to them, as by making these feet of suitable diameter you can adjust your area so as to support any reasonable weight. Mr. Brunlees was the first to use this form of foundation, and by its means carried a railway across the treacherous sands of Morecambe Bay. These sands, he proved, by numerous experiments, to possess at a few feet from the surface a uniform supporting power of about five tons per square foot, and this was apparently not increased if you went down to a great depth. He sank the iron piles by means of hydraulic pressure, conveyed through the center of their columns down to their feet, thereby disturbing the sand beneath them, and allowing them to sink to the desired depth, when the pressure being withdrawn the sand returned to its former consistency, and the piles remained stationary.

Leaving for a moment the character of the soil, I will notice the pneumatic process of sinking and excavating large cylinder foundations under great external water-pressure. This was first introduced by Mr. Hughes in the building of Rochester bridge. In this case some of the cylinders were nine feet, and some six feet in diameter. The joints of the several lengths of cylinder were made watertight, and a wrought iron cover securely bolted to the top. Through this cover two cast iron chambers project two and a half above the top of the cylinder, and three and three-quarter feet below the cover. These chambers form air-locks, one for the passage of men and materials, and the other for buckets containing the materials excavated. These air-locks are furnished with cocks communicating from the interior of the cylinder to the chamber, and from the chamber to the atmosphere. The cylinders were filled with compressed air at a sufficient pressure to withstand the head of water on the outside of them. To pass into the cylinder the air in one of the chambers by means of one of the cocks is lowered to the pressure of the atmosphere, and whatever is to pass enters the chambers, when the door is closed, and the cock communicating with the inside opened, by which the pressure is gradually raised to that within the cylinder, when you can pass from the chamber into the cylinder. To come out was the same process reversed. There was a pipe in the form of the siphon, the longer leg of which reaching to the bottom of the pile, was subject to the pressure of the condensed air on the surface of water within, while the shorter leg leading into the river, had the effect of relieving the cylinder from any unnecessary or irregular pressure, doing the duty of a safety-valve, as well as of an outlet for the continual charge of air. The greatest depth of the foundations at Rochester was about sixty-one feet below high water; but in the construction of the foundations of the St. Louis Bridge in America, on the same principle, part of the work was executed under a pressure of 102 feet of water.

When an act for constructing a railway under the Humber was applied for some few years since, the engineers to the promoters designed an ingenious adaptation of this principle. It was proposed to build the tunnel, which was not to be anywhere more than a few feet under the bed of the river, in small sections, using an oblong chamber as a sort of diving-bell, excavating the river-bed, and building a section within in, and jointing it to the next section by brickwork set in cement under water as the work progresses and the air chamber is raised. The excavation would be in river silt and chalk rock.

In carrying out works in the neighborhood of London, we have frequently to encounter what is—especially if on the side of a hill—one of the worst foundations, that of the London clay. If it is in an evil mood, it gives you but short notice. I have known an excavation look as right as possible overnight, and in the morning found the ground had surged in on us, breaking strong timbers, as if they were lucifer matches. This soil, as a rule, does not slide or part piecemeal, but seems to wait till the whole mass is of the same mind, and it then comes on you with a quiet and almost irresistible energy. There would appear to be slippery seams in it, which contain or allow of the transmission of water, and the upper part will slide forward upon one of these seams, so that if you fairly disturb and set the mass in motion, you can easily understand that instead of an ordinary case of angle of repose, it is a hillside with which you have to deal. The only thing is to meet it at right angles, and to disturb as small a section as possible at a time, so that any forward impulse may not be communicated to the mass, and to take care that you have strong cross-walls in your basement to act as buttresses.

In clay more particularly you must be careful to carry your foundations down to or below the ultimate drainage level, as by any subsequent draining of the subsoil, it is caused to shrink, and is the occasion of ugly and sometimes disastrous settlements. I have been fortunate generally, but in one case where the money was pinched, I thought we need not carry the foundations of a portion of the building, which was only one story high, down to the depth required for the remainder, where the walls were not only lofty but very thick. The drainage caused by the larger part, which contained a basement, so affected the ground that the outer corner of the small part with shallow foundations settled considerably. For this, the just penalty of underpinning to the proper depth had to be paid.

In another case a permanent water-level was thought to have been left just half-way up the concrete, for at any time during the building, by opening the ground anywhere in the basement, the water would in a few hours rise in the hole to that level and never above. This looked satisfactory; but within a few months another of those useful but unpleasant Metropolitan railway extensions similar to the one referred to at the commencement, was constructed, with, of course, a drainage considerably below the level I had established. It is, however, some distance off, and the house was also thoroughly well set, and so far no damage has occurred. In this case, the outside of the walls were asphalted all round up to the ground-level, varying from six to twelve feet, and by this means the building has been kept eminently free from damp, though nothing can be wetter and colder generally than basements or foundations at that depth in the London clay.

In another case, when building the eastern end of a large church on the top of a clay hill, the foundations had to be taken down about five feet below those of the adjacent walls, and in which an old settlement had taken place, passing from the ground right through the aisle and also through the clearstory wall, up to the eaves. This looked risky, and under the circumstances I kept the concrete foundation of the new walls at as great distance as I dare, and then threw

merged, it endures for centuries, and the supporting power of timber piles is a subject treated of in the office textbooks, for both architects and engineers, and does not need comment for me. This description of foundation is the same as that which used to be employed for bridges across the Thames, but is now generally abandoned, it being considered preferable to take your foundations, cylinder or otherwise, down to the London clay. In the case of Waterloo Bridge the recent improvements in the shape of embankments have so increased the scour of the river that the bed is now in several places some feet below some of the timber platforms, and measures are now being taken to strengthen and make good the foundations before they settle like old Blackfriars. The late Mr. Page proposed a plan, I believe, for putting in cement concrete under existing foundations by means of a spoon and bag.

Viollet le Duc, in his "Dictionary of Architecture," states that the ancient Romans always founded their buildings in the most solid manner, by means of large blocks of concrete composed of quarry rubbish, of gravel, sometimes of burnt earth and an excellent mortar. This formed under the superstructure homogeneous basements, and the Roman foundations are veritable artificial rocks, upon which one could place the most heavy buildings without any fear of rupture or settlements. During the later Roman period the foundations were much neglected, and the architects of the twelfth century had seen so many instances of important edifices fallen by reason of bad foundations, and of arches badly buttressed, that they paid particular attention to establish durable foundations, and to render their constructions so elastic that settlements were not to be feared. To them succeeded others, who sometimes, at the request of the ecclesiastical authorities, when means were not plentiful, attempted to make a grand or attractive show of buildings at little expense, and putting in mean and inadequate foundations, occasioned the subsequent failure of some most important edifices. Thus periods of good and bad foundations have succeeded each other like tides, or action and reaction.

In conclusion, I can only express my regret that the time at my disposal has really been so small, that I feel I have not done the subject anything like justice. I would, however, take the opportunity to urge upon everybody to whom building is intrusted, its great importance; and that though the money to be spent upon the entire work may be small, it is not in the foundations that they should be parsimonious. Let the superstructure or ornamentation be curtailed—they can be extended or attended to later on, when money may be a little more easy; but your foundations once put in, as a rule have to remain, or at any rate, do remain in the state in which you finish them until after a possible catastrophe has happened.

CONCENTRIC SPRING PUNCH FOR CUTTING OUT WASHERS.

THE manufacture of washers requires two successive punchings, and consequently takes considerable time and is attended with no little expense. The present methods in use, then, do not entirely meet the wants of the various

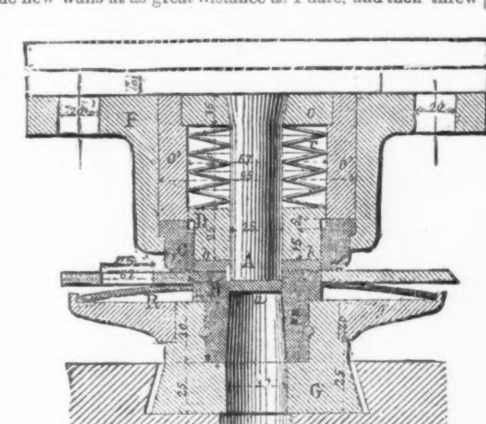


FIG. 2.

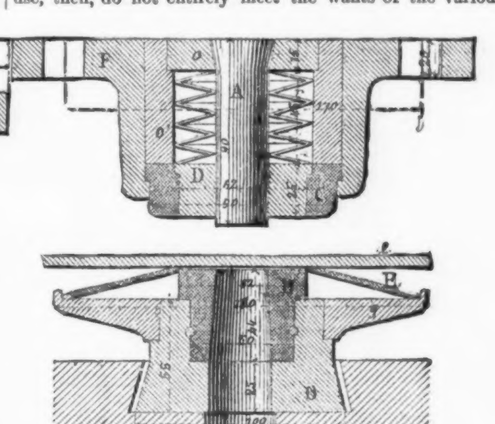


FIG. 1.

AUTOMATIC PUNCH FOR CUTTING OUT WASHERS.

up from them an arched buttress against the old walls and built that portion of the new wall upon it. We pointed up the old settlement before commencing, and this did not open in the least, thus removing much anxiety during the process.

Adding to or making a junction with an existing building is, however, always attended with some anxiety, even where the foundations are of the best character. Not only is it well to put up all the walls of a building at the same time, and, if necessary, leave the completion of the interior, but it is also far cheaper; more than one building with which I have been connected having cost more from the postponement of portions, and being done piecemeal. If you can do no more, you ought to make an effort to have the whole of the foundations put in at the same time, so that *they*, at least, should be solid and homogeneous. Even then it will be difficult to secure a perfect bond with the toothings left out for you from the old part, as all ordinary brickwork or masonry will settle a little or compress the mortar joints. Some of our best builders, in fact, prefer, because of this, to make a junction by building into a groove or chase cut in the old walls to attempting to bond fresh work into the teeth of the old.

With regard to the weight imposed on the foundations, or lower courses of buildings of any great height or weight, it is also necessary to consider what kind of material you are using, as very recently the tower and the western wall of a church a short distance from London have had to be underpinned on account of the lower courses crushing, the stone used having been an inferior kind of Kentish rag. It is very seldom you come across so weak a stone, but it is well to know that it is possible to do so. No brick that would be fit to be passed as fit for any part of a good building would be liable to be crushed.

There is one kind of foundation which I have hardly touched upon, viz., timber piles with a strong timber platform on the same. This is a very common foundation in Holland. Generally, when the timber is constantly sub-

industries which use large quantities of these objects, and which demand more rapid and economical processes.

Mr. Charles Schwab, having given this particular problem considerable attention, has just invented a system of concentric spring punches which permit of the washers being cut out of a sheet of iron plate at a single operation. This new tool is very easily operated, and possesses the great advantage, besides, that it can be adapted to any one of the punching machines at present in use.

The apparatus is represented in section in the two accompanying cuts. Fig. 1 shows the respective arrangements of the different parts before the descent of the punch; and Fig. 2 shows the punches during their operation, that is to say, when the tool-carrier has reached the end of its travel.

The parts which effect the cutting are three in number: (1) A central piercing punch, A, of steel; (2) a second punch, B, also of steel, for doing the external cutting, and serving at the same time as a matrix for the former; and (3) the matrix necessary for the operation of the punch, B.

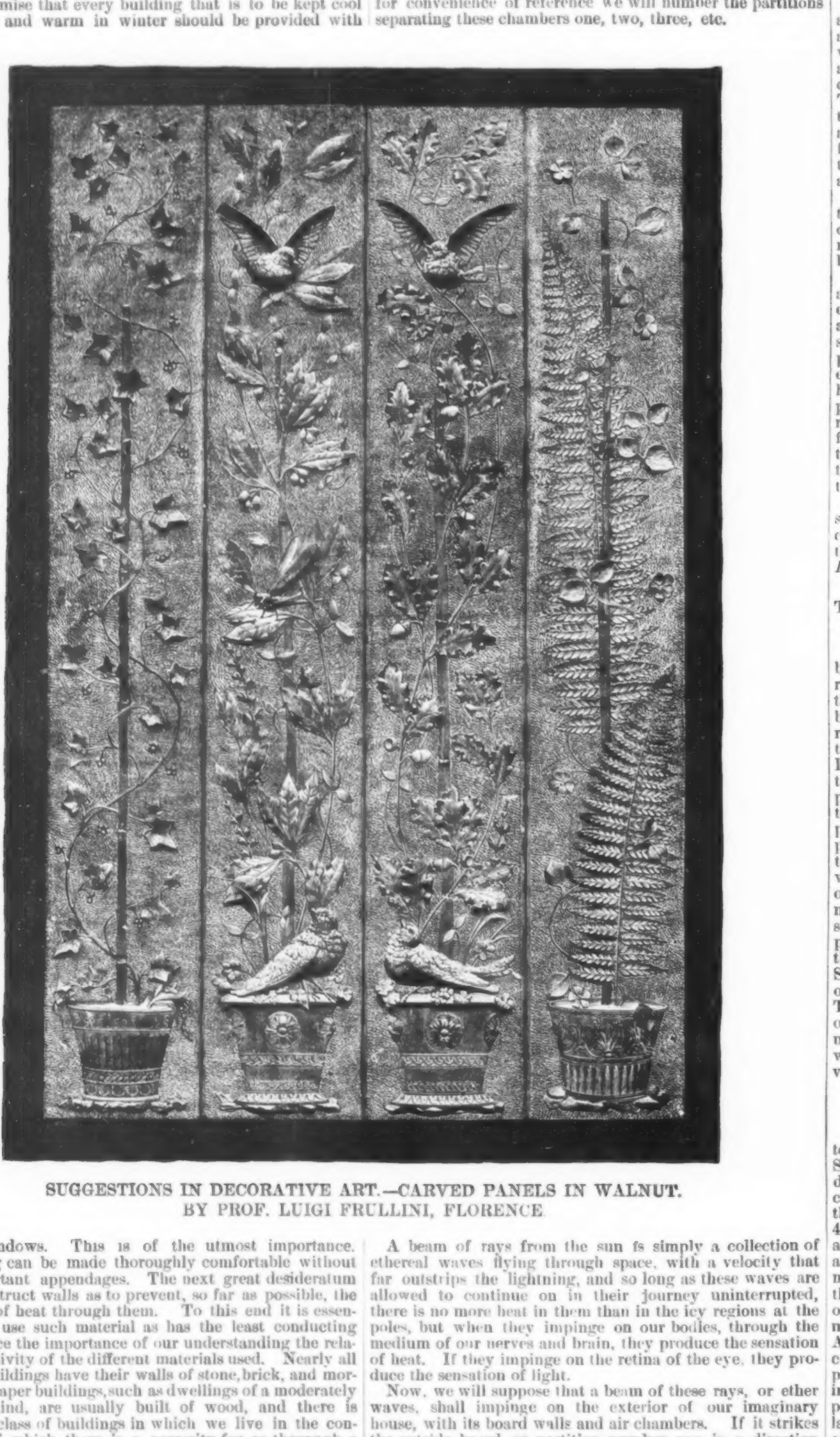
The other parts serve either for the disengagement of the perforated pieces or for that of the iron plate. Thus, the part, D, which is of iron, acts under the pressure of the spring disks, *r r*, when the tool-carrier begins to ascend, and holds the cut out washers in their initial position, while the large steel spring disk, E, disengages the iron plate, *t*, after each perforation, and allows it full freedom to move forward.

In the interior of the tool-carrier, F, there are bushings, O and O', for the purpose of keeping in position and guiding concentrically the parts just mentioned. Finally, the iron matrix carrier, G, is encircled with an iron ring, *g*, which supports the spring disk, E, and is hollowed out internally for the reception of the extremity of the central punch, A, and the newly formed washer. The operation of this apparatus is entirely automatic, and it is impossible for it to get out of order.

The sheet of metal, *t*, to be punched, and which may be of

any thickness, is supported by the disk, E, and moves forward between the punches, A and B (Fig. 1), during the ascent of the tool-carrier. When the latter again descends (Fig. 2) there is effected a double punching, one external and the other internal. The central core, *a*, alone falls to the base of the machine, while the washer, *b b*, that has been punched out, remains held between the spring piece, D, and the matrix punch, B. As soon as the tool-carrier begins to ascend again the springs, *r*, bear against D, which takes its initial position and disengages the washer; so that there is thus nothing to prevent the plate from moving forward to be converted into washers.

As above stated, Mr. Schwab's system of concentric steel punches is applicable to all existing punching machines, even to those of the smallest power, and renders the production of metal washers much cheaper than does any other process now in use. In addition, washers made by this new apparatus possess the advantage of being perfectly concentric and well finished.



SUGGESTIONS IN DECORATIVE ART.—CARVED PANELS IN WALNUT.
BY PROF. LUIGI FRULLINI, FLORENCE.

HOLLOW WALLS IN BUILDINGS.

A SALUBRIOUS and comfortable atmosphere in winter is best attained when houses are so constructed that they can be heated with the least possible amount of artificial heat.

I will premise that every building that is to be kept cool in summer and warm in winter should be provided with double windows. This is of the utmost importance. No building can be made thoroughly comfortable without these important appendages. The next great desideratum is to so construct walls as to prevent, so far as possible, the convection of heat through them. To this end it is essential that we use such material as has the least conducting power; hence the importance of our understanding the relative conductivity of the different materials used. Nearly all first-class buildings have their walls of stone, brick, and mortar. The cheaper buildings, such as dwellings of a moderately expensive kind, are usually built of wood, and there is perhaps no class of buildings in which we live in the construction of which there is a necessity for so thorough a knowledge of how to build as in this class of houses.

The relative conducting power of the different building materials is as follows:

Stone	14 to 16
Brick	5
Plaster	4
Wood, less than	1

Wood, therefore, is the best material named; but woolen felt is now much used in place of wood, and is probably better for many purposes.

Various considerations, however, may govern our choice and necessitate the use of stone or brick. When this is the case, it is an excellent method to fur the walls inside with ordinary furring strips, then sheathe or cover them with this woolen felt, and against the face of each furring and over the felt, fur again for lath and plaster. This is an interposition of what we have shown to be a comparatively good nonconductor, and with an air chamber on each side of it, between the brick and the wood on the one hand, and the lath and plaster on the other, it is perhaps the best method of preventing the convection of heat through walls. Hollow brick walls are sometimes resorted to; but if the two sections of the walls are so completely separated as to entirely break the continuity of the brick, the walls are weakened. It is a popular error that a wide space or air-chamber in a hollow wall is better than a narrow one. This error is founded entirely on a misconception of what heat is, and how it travels through space.

For the purpose of making our demonstrations as clear as practicable, we will assume that the material of our building is chiefly wood, and that it is desirable to prevent the convection of heat as much as possible. For the illustration of a principle, and without reference to stability of construction, we will suppose our wall to be made of a series of close board partitions set a little distance apart to produce chambers for "dead air." We shall endeavor to show that these chambers will be equally efficient as nonconductors whether they be one or ten inches in width, and for convenience of reference we will number the partitions separating these chambers one, two, three, etc.

A beam of rays from the sun is simply a collection of ethereal waves flying through space, with a velocity that far outstrips the lightning, and so long as these waves are allowed to continue on in their journey uninterrupted, there is no more heat in them than in the icy regions at the poles, but when they impinge on our bodies, through the medium of our nerves and brain, they produce the sensation of heat. If they impinge on the retina of the eye, they produce the sensation of light.

Now, we will suppose that a beam of these rays, or ether waves, shall impinge on the exterior of our imaginary house, with its board walls and air chambers. If it strikes the outside board, or partition number one, in a direction perpendicular to the plane of the board, a much greater portion of the beam will be absorbed and transmitted than if it impinge upon the board obliquely; but in either case a portion of the beam, depending on its angle of incidence, will be absorbed and transmitted in accordance with the laws of convection, and the remainder will be reflected back into space, or to the surrounding objects, in accordance with the laws of reflection.

When this beam has impinged upon the surface of this partition number one, that portion of the beam that is absorbed enters among the molecules of the wood, and sets them in active motion one against another, and now, for the first time, our rays become heat. Before they impinge on the wood they are simply motion—a wave in ether, similar to a wave on the surface of the water, and these waves that are reflected off continue as motion, and are only changed into heat when they find a lodgment in some material substance.

We have now advanced to that point in our demonstration where we have our ethereal waves absorbed in the first surface of the first partition, from which it is transmitted from molecule to molecule until the heat has found its way through to the second surface of board number one, and this transmission is technically called convection. At this second surface the heat is again changed into ethereal motion, and, again taking the form of a wave, it jumps across the intervening space to the first surface of the second partition. I have said that the distance across this air-space makes no sensible difference in regard to the transmission of heat, and for this reason, that it travels through its medium, the ether, at the rate of nearly 190,000 miles per second; hence, practically, the difference of a few inches, or feet even, is unimportant.

We take our beam where we left it at the first surface of the second partition, but we find only part of it—for a considerable portion was reflected back from the first surface of the first partition and lost. It is, however, sufficient for our present purpose to know that it has not entered the buildings.

Our beam, or what is left of it, has been absorbed and again changed to molecular motion—that is to say, heat; and another part of it reflects back to the first partition, where it is again reflected in part, and the remainder is absorbed, and transmitted by convection to the first surface of the first board, and sent back into space as ether waves. That portion which has been absorbed by partition number two will be transmitted through this partition by convection, as through the first partition, and so this process goes on from partition to partition, until, if there be enough of them, the whole beam will be turned back and dissipated, and no sensible amount of heat will get into the building.

If walls of brick, stone, iron, or other material are used that have a greater power for absorbing these waves and converting into heat, a smaller portion of the waves will be reflected back each time, and a proportionately greater number of compartment partitions will be required.

It has been claimed that the wider air-chamber is preferable to the narrower one, for the reason that the ray of heat emerging from a given point diverges, and that its intensity at the next surface on which it falls is inversely as the square of the distance. We admit the correctness of this principle, but we should not overlook the fact that the entire second surface of our partition, instead of giving off heat waves at a single point, is emitting them at every point on its surface, and each and all of these diverging rays are crossing and overlapping each other, so that in fact the same amount of heat that leaves the first reaches the second partition, diminished only by a small absorption of these rays by the vapor in the air-chamber, which is quite too small to be considered in the general result.

The advantages to be derived from a thorough understanding and a skillful application of these principles in the construction of compartment-walls, by which to prevent the transmission of heat through them, is very great.—*G. P. Randall, in Amer. Architect and Building News.*

THE GNAWING OF GAS AND WATER PIPES BY RATS AND MICE.

AT the last meeting of the Royal Physical Society of Edinburgh, Mr. A. Gallatly, of the Museum of Science and Art, read a paper on the above subject. After a few remarks on the dentition of the *Rodentia*, to which order rats and mice belong, Mr. Gallatly exhibited a number of specimens of rat and mouse gnawed pipes he had obtained from plumbers; the pipes being water-service pipes, soil-pipes, and gas-pipes. It struck him, he said, that rats might more frequently be the cause of leakage in water-pipes than was commonly suspected. The gnawing of pipes by rats, however, appeared to be more common about Glasgow, Dundee, and some other places than in Edinburgh. Several opinions had been expressed respecting the purpose for which rats gnawed the pipes. Some thought it was done simply to get at the water; others that it was because the pipes were in the way of their tunneling operations; others, again, that it was merely for the love of gnawing. The most extraordinary specimen of a rat-gnawed pipe which he had seen was a piece of water-supply pipe three-sixteenths of an inch in thickness, thirteen square inches of which had been removed. Speaking of mice, it was pointed out that their teeth were only capable of cutting through composition gas tubing. Tin plates were pretty nearly safe from their attacks; iron ones completely baffled them. In the course of some remarks made on the paper it was pointed out that the subject was one of extreme importance from a sanitary point of view.

THE CHRONOLOGY OF PETROLEUM.

COLONEL O. C. FERRIS contributes an interesting article to the Bradford *Era* on the early history of petroleum. Some historical facts are here appended in the order of their dates which will put every man in the right place with due credit, and untangle some of the web of mistakes in which the facts are entangled. Herodotus, the Greek historian, 440 years before Christ, relates that there were wells of oil at Anderrica called "Rhadiance," which was black and had an unpleasant odor. In 1694 Eele Hancock and Portloch made "oyle" out of a kind of stone, and obtained patents therefor. In Lewis's "Materia Medica" of 1761 it is stated oils were distilled from bituminous shale and employed for medicine. The first discovery of petroleum was made in America by soldiers of the army of General Sullivan, under the command of Colonel Brodhead, on their return from the expedition against the Seneca Indians in our revolutionary war in 1779 (Frank Moore's "Diary of the Revolution," vol. ii, page 218). In 1806 Nat Carey, a peddler, began an oil speculation in Oil Creek. Carey gave the oil the name of "Seneca oil," from the fact that its virtues had been made known to the whites by "Red Jacket," the great Seneca chief. Later General Hayes, of Franklin, shipped three barrels of the oil by wagon to Baltimore. On its arrival the firm to whom it was consigned dumped the oil in Chesapeake Bay and burned the barrels. Petroleum was distilled for light in 1810 to 1817, by J. Hecker and J. Mitis in Truscovitch, Austria. And naphtha and mineral oil were formally tested by an official commission of the city of Bayne; but it failed to succeed for the want of a lamp (Herr Heinrich Walter). Petroleum turned up again in 1838, in a lawsuit for revenue, and was decided to come under the head of minerals in Starunta (Herr H. W.). In 1853 or 1854, a man named Schrenier discovered its use for light, but equally failed to utilize it for commerce, and it was yet being experi-

mented upon when a German named Toch, who built the refinery at Tarentum for Lewis Peterson, Jr., and Dr. Dale went to Vienna, and taught them the American method of refining the oil (Herr H. W.). Then follows Mr. S. Kier's efforts, as before detailed, which were supplemented by Nevin, MacKeown & Co., in March, 1857, both experimenting with the oil, but unsuccessfully, trying to use it for light in such lamps as were in common use. But up to this time all efforts to utilize it had failed, as it did not find favor with the public, and the people could not burn it with its intolerable smoke and nauseous odor, and this led Mr. Kier to advertise his offer of $1,000 for a lamp that would burn the obnoxious oil.

In November, 1857, A. C. Ferris sent his first shipment to New York for experiment, afterwards contracting with MacKeown & Co. (successors to Nevin, MacKeown & Co.) for the product of the Irwin and Peterson well. After succeeding, as before described, in burning it successfully in a lamp that met with popular approval, he utilized the oil from Canada and California and also from Europe, thus establishing petroleum as an article of commerce.

Next comes Mr. J. M. Williams, with the first successful well in Canada, dug with pick and shovel prior to 1858, followed by a number of wells or pits yielding oil at Enniskillen. A well was also bored expressly for petroleum by T. W. Nevin & Co., in 1858, in Greensburg, Pa. After boring about four hundred feet and failing to "strike oil," they abandoned the effort. Had they succeeded, this would have been the pioneer well of the United States.

Then follows Colonel Drake with his noted well on Oil Creek in 1859, which opened up the great deposits to supply the demand that, through the efforts of A. C. Ferris, had been created. But the reality exceeded the expectations of all the pioneers in oil.

It is plainly apparent that no man can claim the "discovery" of petroleum; that Mr. Thier was not the inventor of the "present mode of refining," nor was Colonel Drake the "founder of petroleum business." But if the efforts made before the writer took hold of the oft-rejected oil had gone no farther than they had up to that time—1857—the world would have been in darkness yet (as far as petroleum lights it), and the millions that it annually produces to the country would yet be locked in darkness in the bowels of the earth.

In regard to the Canada petroleum, which preceded the Oil Creek oil, to show it was not a small sample, as some have stated, I give below the first transaction from my books made at Hamilton by the writer with Mr. J. M. Williams, in October, 1858: "November 19, paid J. M. Williams, $100; November 22, paid his draft in New York, $1,785; expense of A. C. Ferris to Hamilton, $58; gauging, $6.98; bill paid for labor, $38.33; sundries, $2.38; cartage, etc., $8; Custom House duties, $285; freight Hudson River Railroad, $441.78; total, $2,723.57." Before this I had never seen any oil but the Tarentum, which, before distillation, had no unpleasant odor, and was of a semi-transparent amber color, in no way offensive. The Canada oil was black, nauseous in odor, and in papers which I have in my possession, complaints are made of the horrid odor which for days after its transportation was experienced all along the line of the Hudson River Railroad. This obnoxious oil of concentrated nastiness I invested nearly $3,000 in before attempting distillation, which at least shows enterprise in that direction. After obtaining it, Mr. Williams knew not what to do with it, and Ward never received one cent for his efforts in obtaining it; but encouraged by my cash purchase, and learning what I intended to do with it, he put up a still and bored more wells, and so became the foremost oilman in Canada. For this he has received gold medals and a life position from the government, which he has filled for the last twelve years. He was the first man to obtain petroleum on this continent by digging a well for it, Nevin & Co. the first to bore expressly for it, and Drake the first to bore for it with success.

In a former article you spoke of history not sustaining my claim as the "founder of the business." But you will find me on record as such in Gessner's work on coal and petroleum oils, published by Ballentine & Co., and my utilization of it was timely for the aid it brought the country when the export of cotton ceased during the war.

USES OF PETROLEUM.

Petroleum enters largely into the manufacture of nearly all of the more common oils. Even the lard oil trade seems likely to suffer more or less at its hands. Aside from the illuminating and lubricating qualities of petroleum, it has a thousand others which are daily enlarging their demands for stock. It has been well known for a few years past that it has been used as an alkali in forming most elegant soaps and general toilet mixtures which have been manufactured from petroleum products, and even hair restoratives of excellent quality are compressed from it. But there are still other and perhaps greater sources than these for its consumption, and this remarkably lengthy season of over-production has had a tendency to force it upon the tradesmen in all parts of the world. Its cheapness has accomplished much more than those who produce it are aware of in the matter of new uses. In Europe, however, which seems a peculiar circumstance, nearly all of the new methods for its utilization first appear, and especially so among the French.

It is said that there are hundreds of dealers in patent medicines who are reaping large fortunes from the sale of petroleum products as ingredients of their mixtures. It is possible, if not probable, that it will yet take the place of many of the compounds administered by regularly authorized physicians for skin diseases and rheumatism. But the latest phase of this rising moon, as seen from a French standpoint, is in its constituting a very effective stimulus. By it the vitality of declining manhood is restored, which is an idea entirely new. When this fact, if fact it may be termed, becomes thoroughly known, we may expect a large delegation of the sexes who have passed the meridian of life as devotees to its hollowed shrine. This, in America especially, should cause a vast and decisive increase in the consumption of the article, as it is said there is no country in the world in which there are such numbers of the classes named. It is an encouraging feature, not only because of its beautifying and youth-giving effects, but because it is proposed to furnish us with an alarmingly cheap stimulant instead of the deadly drugs dealt out to us by the average bartender. When they get to manufacturing first-class wines and liquors from petroleum, it is presumed the whole force of operators will go off on a bender. It is certain the liquid has a neutralizing effect upon the nerves, for sometimes men become so overcome by inhaling it that they lie down never again to rise. At that day we expect to see a large advance in the price of the article.

But the subject at hand demands a more serious and careful consideration. There are those who are firm in the belief that its use, as applied externally, has preserved the original color of the hair. Others have had their teeth preserved and beautified, and even had their breath perfumed by its delicate odor. It is said to be largely used in the manufacture of what is termed in this country as "West India molasses." And brown sugar, beeswax, chewing gum, sperm candles, and in fact everything of a soluble character used in the various channels of domestic necessities, come in for a share of some product of American petroleum. Into the various mixtures of paints and varnishes it also enters to an extensive degree. All these are simply evidences of a most rapid increase in the consumption of the article. It is a small matter at first thought, it is true, to supply all the requirements of the world in either of the cases named, but when all of the forces are combined the alliance becomes most powerful and effective.

Thus, step by step, the use of petroleum becomes more and more general; and, judging from appearances at the present time, the value of the product—not as an integral, but as forming an important component in the various articles above—has not been fully appreciated. The numerous attempts that have been made to introduce it as an agent of motion have not, it is to be regretted, proved as successful as the trade might desire; yet, notwithstanding, it is destined to play an important part in this particular line at an early day. We understand two valuable inventions, having in view the utilization of petroleum as a motive power in the commerce of the seas, are now about to be applied for, and the results will be awaited with great interest. Then, moreover, there are possibilities of its forming an interesting part in the gas supply of many of our larger cities. As it is strictly a combustible substance, easily transmitted from a liquid to a fluid state through the process of heat, which may be engendered by the combustion of a small quantity of the liquid itself, there would appear to be no just cause why it should not form a most substantial basis for the production of gas.

Unless, therefore, the daily yield falls far below the total requirements of the trade, by which the prices are to be elevated beyond the limit at which other and opposing elements are utilized, there is no doubt but that the field for the uses of American petroleum will be wonderfully enlarged in the near future. There is greater diversity in its utilization than in any other mineral product known to the age, and there seems no limit even yet. We are truly living in an age of advancement in the uses of petroleum.—*Petroleum Age.*

ACCUMULATION OF PETROLEUM IN FISSURES.

Professor Andrews has observed in Virginia and Ohio, and Professor Hunt in Canada, that the accumulation of oils is intimately connected with the anticlinial disturbance in the rocks; and wells sunk in these anticlinials often give abundance of oil, especially where the fissures are most numerous, while no oil has been found in the horizontal rocks on either side. In determining the origin of the oil in any given locality, however, we must always consider that the true source of it may not be in the rock which appears there at the surface, but in some underlying formation. Thus, in Western Pennsylvania and in Ohio, although natural oil springs appear at the surface, many of the productive oil-wells are sunk to the depth of several hundred feet in the great Devonian sandstone, which there attains a thickness of nearly two thousand feet. In other places in that region they are sunk in the still higher carboniferous rocks, which in many parts rest upon this sandstone.

Coming northward into Canada, we find the oil-wells of Enniskillen sunk in shales which, from their softness, are locally called soapstone, and at a depth of two hundred feet or more rest upon a limestone formation known as the Coniferous limestone, which underlies a considerable portion of Western Canada. If the fissures in the oil-bearing rock along the anticlinials are open to the surface, the oil will flow out and be lost. If, on the contrary, this rock be overlaid by higher formations of different texture, which have been exposed to the same strain along the anticlinial, irregular rents or fissures may occur in these, into which the oil will rise and accumulate, together with water and with gas, which follow the same law as the oil—the fissures being often more or less completely closed above by plastic clayey strata, which do not permit the oil to filter through, but become reservoirs. Another case may be that of overlying porous beds in which the oil finds a lodgment, and, from the nature of the surrounding strata, rests imprisoned. An instance of this was met with at Enniskillen, where, above the soft shales and beneath the surface clays, was a gravel bed filled with oil which had slowly come up from below, and had been retained there perhaps for ages. This stratum was the source of the so-called surface wells, after exhausting which, borings were sunk in the shales below, and at various depths often penetrated the irregular fissures or veins, from which very large quantities of petroleum were obtained.

We find over great areas of the oil-bearing limestone of Western Canada but insignificant quantities of petroleum; and the reason of this is that the strata are often nearly or quite horizontal, and have not the arrangement required for its accumulation, or the absence of overlying strata has allowed it to run to waste. Thus, at Tilsonburg, where wells have been sunk in the limestone itself, which is covered only by a few feet of clay, the amount of oil is small; while in Enniskillen, where the limestone is overlaid by more than two hundred feet of fissured shales, which, in their turn, are covered by beds of gravel and clay, all helping to retain the oil, the wells sunk to various depths in the shales yielded in little over a year (1861-62) about 16,000,000 of liters of petroleum, and still continue to furnish it, though in less quantities. In Pennsylvania and Ohio the oil-bearing rocks, which are near the surface in Canada West, dip beneath the great masses of Devonian sandstone and shale. These have furnished reservoirs for the oil, and hence the wells along the anticlinials in those regions are still more productive than those of Canada.

It thus becomes very important, in searching for petroleum in an oil-bearing region, to determine the position of the anticlinal axes. These are not necessarily marked by any irregularities of the surface, for the folded strata were, ages since, partially worn away by the action of the elements; and as the surfaces thus planed, and often sculptured into hills and valleys, are now covered over by sands and clays, which, in Western Canada, give us but few opportunities of seeing the rocks beneath, it is only by actual inspection of these at numerous points, and by the contours of the outcrops, that we can determine their attitude. It will be understood that the beds of rock, on the two sides, slope away in opposite directions at a greater or less angle.

In all the cases just described, Professor Andrews supposes that the oil is a slow subterranean distillation, and that such distillation is still going on; this he infers from the immense quantity of gas thrown off from such bituminous shales, furnishing abundant sources for gas used in illumination and heating.

AMERICAN PETROLEUM EXPORTS.

The largely increased exports of petroleum from the United States during the last half of 1881 have created a popular impression that foreign markets must be overstocked with this commodity. It will be remembered that during the first quarter of the year there was a considerable deficit in the exports as compared with 1880, but that the subsequent increase in the shipments have caused an excess up to December 17 of 188,000,000 gallons over last year. This excess amounts to about 47 per cent., and is equal in gallons to the entire export of 1873. It has been assumed that these excessive exports must represent heavy stocks at some point, but they certainly do not appear in the reported stocks of any of the principal foreign ports. Mail advices to December 3 give the following stocks, as compared with the quantities held at a corresponding date last year:

	1880. brls.	1881. brls.
Bremen	680,186	355,055
Hamburg	72,713	67,915
Antwerp	161,610	286,626
Rotterdam	35,727	11,853
Amsterdam	51,526	51,021
Stettin	43,907	47,416
Dantsic	17,082	43,907
Total	1,062,751	863,793

The afloats and loadings bring the visible supply this year up to 1,326,000 barrels on December 3, against 1,304,000 last year. There has been an excess of 22,000 barrels contracted for and shipped to these seven continental ports, but this has been more than set-off by the increased shipments to the interior of Europe, where a considerable quantity of oil is doubtless still stored.

The low prices have undoubtedly led to largely increased consumption in all countries, however, and the heavy exports which have been made to the Far East, and which have helped to swell the volume of the year's exports, undoubtedly represent a growing consumption, though they are also to be charged in some measure to speculative purchases. Low prices may, however, be regarded as an assurance of increased consumption, and the actual demand for oil during 1882 may be greater than ever before. As to how prices will range during the year, no man would be rash enough to predict. Competition is active among refiners, and the perseverance and energy displayed by the independent refiners in marketing their products, and the popular sentiment against monopoly which is spreading with gratifying rapidity throughout the trade and among consumers, are circumstances that insure the successful building up of an independent interest which shall surpass in extent and power the combination which two years ago had so nearly accomplished a monopoly.

THE CANADIAN PETROLEUM MARKET.

By this week's advices from Canada we learn that, in order to work off the old stocks of refined oil in Montreal, dealers have been compelled to accept lower figures, and car lots may be quoted at 18c. to 18½c. per imperial gallon. Broken lots have sold at 19c. to 19½c., and single barrels at 21c. to 22c. Great complaints are heard on the score of cutting prices, but it is difficult to say how those dealers who want to realize can well avoid it. Refined oil is being offered at 16c., f. o. b., at London, Ontario. Of course, present prices mean a loss to those who have had stock accumulating for some time past, but the outlook at this moment certainly does not favor the policy of holding for better figures. The reason of the present large supply in Montreal is said to be due to the general belief which prevailed some time ago, that the market would take an upward course, inducing buyers to look too far ahead.

COLORADO AS A PETROLEUM PRODUCER.

It is generally known that active operations are soon to be begun in developing the petroleum resources of Colorado, thereby adding a decidedly important element of wealth to the State. Surface indications of this valuable oil have been found in various parts of the State, principally near Morrison, Canon City, and further south, as well as at intermediate points. These indications have been examined by competent men from the famous oil regions of Pennsylvania, and they all agree that Colorado must not only possess immense quantities of petroleum, but that it also exists of an unusually fine quality. Three or four companies have been organized to bore for the fluid and to refine it for the market, and the results of their labors will be looked for with interest.

The Colorado Oil, Coal, and Gas Company (of which Dr. Reuben Jeffrey is president, R. W. Kennedy secretary and general manager, L. J. Ingersoll treasurer, and Mark Luckenbach superintendent) are about to begin energetic labor upon their properties. They have secured upward of 2,000 acres of oil land, on which not only is oil found, but also coal of an excellent quality. The latter deposits will also be developed. The company starts with a capital of $2,000,000, divided into 20,000 shares of $100 each, and in addition to their other franchises they also own a process for the manufacture of gas from petroleum, which is claimed to be better and cheaper than the ordinary coal-gas. It is announced that they are now ready to enter into contracts to supply cities, towns, villages, manufactories, deep mines, etc., with this gas, and, it may be, a new industry of no small proportions will soon be in active operation in the State.—*Denver Tribune.*

PETROLEUM DEPOSITS IN CALIFORNIA.

The deposits of petroleum in California will attract more and more attention with each passing year. There is no doubt that they are very extensive and valuable. They exist at various points from Los Angeles to Humboldt. The recent showing in San Mateo was very encouraging. The Santa Barbara *Press* reports great activity in the oil regions of the Santa Clara Valley of the South. New wells are being sunk, and there is increased development and confidence. A well in Sespe Creek Cañon is pumping forty barrels a day. The refinery at Newhall is manufacturing $3 000 worth of oil a day, and a car-load is sold daily for heating purposes in Los Angeles alone. The pipe line from the Sespe wells down to the stage road, six miles, will possibly be extended within the coming year to Newhall, twenty-six miles. Another pipe line is to connect the Pico well with the Newhall refinery. The oil-belt is said to run all the way from the eastern line of Santa Barbara County to More's Landing, and possibly to the Gaviota Pass, so that Santa Barbara is certain to partake in the prosperity that will attend future development. The day is not very far distant when the petroleum product of the State will be very large, adding materially to the general welfare.

THE IRON TRADE AS A CONSUMER OF FUEL.

How large a consumer of coal the iron trade is, Mr. James M. Swank, the efficient secretary of the American Iron and Steel Association, shows fully in his report to the Census Bureau, the figures given by him covering the year ended June 30, 1880. The anthracite furnaces took 2,615,182 tons of that fuel, the bulk, of course, being used in Pennsylvania, which is credited with 1,921 588 tons, while New York and New Jersey are the next largest on the list, with 396,864 and 225,713 tons respectively. Ohio comes to the front as a consumer of 638,711 tons of raw bituminous coal for blast furnaces, Pennsylvania taking second rank with 215,729 tons; the quantity of bituminous coal taken being 1,051,753 tons. Pennsylvania regains its supremacy, however, in the quantity of coke, of which its blast-furnaces swallowed 1,054,452. In their rank, the other States consumed as follows: Ohio, 418,624 tons; West Virginia, 120,737; Missouri, 110,730; Illinois, 101,440; Tennessee, 74,408; Wisconsin, 55,896; Alabama, 42,035 tons—the grand total being 2,128,255 tons. Estimating the average yield at 60 per cent., this would represent a coal tonnage of 2,547,092 tons.

The rolling-mills of the country bought 526,126 tons of anthracite, of which Pennsylvania is credited with 393,348 tons. Of bituminous coal, the rolling-mills of the country used 3,915,377 tons, Pennsylvania leading with 1,807,267 tons, followed by Ohio with 613,105 tons, and the other principal States in their order; New York, 224,722; Illinois, 177,260; West Virginia, 161,191; Indiana, 150,097; Massachusetts, 141,215; and Kentucky, with 104,848 tons. The quantity of coke used by the rolling-mills was only small, figuring up to 14,834 tons, equivalent, approximately, to 24,723 tons.

The open-hearth and Bessemer steel-works, in which modern devices bring down the fuel account to a low point, are comparatively poor customers. Mr. Swank gives the following figures: Anthracite, 140,458; bituminous, 465,655 tons; and coke, 104,980 tons—an equivalent of 174,967 tons of coal. The crucible and miscellaneous steel-works burnt 40,392 tons of anthracite, 224,657 tons of bituminous, and 22,791 tons of coke; while the forges and bloomeries used 340 tons of anthracite, 1,613 tons of bituminous coal, and 6,695 tons of coke.

We have, therefore, a total consumption of fuel by the iron industry of 3,322,498 tons of anthracite, 5,659,055 tons of bituminous coal, and 2,277,555 tons of coke, equivalent, approximately, to 3,792,592 tons, a grand total of 12,774,145. This does not include foundries, machine-shops, car or locomotive works, it being simply the manufacture of raw material and rolled shapes.

The blast-furnace men value the coal and coke they used at $18,237,882, while the proprietors of rolling-mills claim to have paid $10,453,720 for their fuel. To this the open-hearth and Bessemer steel people add $1,908,101; the crucible-steel men, $606,397; and the forges and bloomeries, $36,759—a grand aggregate of $31,242,859. Of course, the bulk of this sum was divided between coal miners and the railroads.—*Coal.*

PRODUCTION OF BITUMINOUS COAL IN THE UNITED STATES.

FROM Professor Raphael Pumpelly's preliminary report to the Census Bureau on the production of bituminous coal east of the 100th meridian, during the year ended June 1, 1880, we take the following figures, which represent the totals and general averages. Coal was produced in 18 States, in 314 counties:

Number of establishments	2,943
Maximum capacity of yearly production in tons of 2,000 lb.	74,154,273
Product of establishments, tons	40,311,459
Value of product at mines	$49,044,498
Irregular product, tons	628,569
Total product, tons	40,940,028
Value of total product at mines	$49,733,603
Value of materials used in mines	$4,661,662
Wages paid to all classes of labor	$30,707,059
Men employed above ground	13,842
Men employed below ground	76,512
Boys under 16 employed above ground	755
Boys under 16 employed below ground	5,366
Total employes	96,475
Number of steam-engines	812
Horse-power of steam-engines	24,726
Value of all machinery, including engines	$2,403,211
Value of explosives used	$963,313
Amount employed as working capital	$8,191,960
Value of plant	$19,453,107
Value of real estate	$62,354,034
Total capital employed and invested in establishments	$89,999,101
Tons paying royalty	13,689,864
Amount paid as royalty	$1,964,076
Acres coal land worked out	56,101
Acres coal land unworked attached to working collieries	206,151
Acres coal land unspecified	204,491
General total of capital, both establishments and irregular workings	$93,517,464
Acres available coal land attached to working establishments	410,642

The maximum capacity referred to represents the number of tons which the operators claim could be raised yearly from the present openings with the present facilities if the market would take it. It is unexpectedly large, and possibly, in some cases, is based on too sanguine estimates. The average time run during the year was only nine months, which would indicate that the capacity of the mines is at least one-third more than the product. The irregular product includes the output of all the small operations, where coal is mined in small quantities for local consumption. In many cases, in some of the bituminous fields, a farmer digs coal from the outcrop on his own farm, and supplies his own and perhaps one or two neighboring families. There were more than 5,000 of these small operations or farmers' diggings reported, averaging less than 150 tons yearly.

An endeavor was made to ascertain the number of acres of coal lands that were worked out. This has not been altogether successful, as in many cases it was impossible to answer the question with approximate accuracy. In other cases, the upper seam only was worked out over a certain area, leaving one or more below untouched, the sum of acres of coal land attached to working collieries is thus found to be 466,743 acres, which is only a very small fraction of the total available coal lands of the country.

From the data given above, the following averages are deduced. They too, of course, relate only to the fields east of the 100th meridian:

Average price per ton of product of regular mines, at mine	$1.22
Average cost of labor, per ton	$0.76
Average cost of material, per ton	$0.12
Average amount left for royalty, profit, etc., per ton	$0.34
Per cent. of capital used for working capital	9·10
Per cent. of capital in plant	21·61
Per cent. of capital in real estate	69·28
Average royalty paid per ton	$0.14
Average yearly earnings of men, net	$328.72
Average per cent. of year worked	75·70
Average per cent. of year idle, except from strikes	17·62
Average per cent. of year lost in strikes	6·68
Tons raised per man per day	1·90
Tons raised yearly per man	431·53
Per cent. ratio of production to maximum capacity	54·36

A very considerable amount of time has been lost in strikes—about 20 days each for every man employed. The data given above show some interesting facts. In the bituminous coal industry there has been an absolute fall in the value per ton of the product, whereas iron ore and anthracite coal have not fallen in price since the last census more than gold has, or rather after falling they recovered, which bituminous coal did not. In spite of the time lost in strikes, the average yearly earnings of a man engaged in mining bituminous coal are very nearly the same as those of the iron-ore miner, being in the former case $328.72, and in the latter $316.08, taking the country at large. In the bituminous industry, the percentage of the value of the product obtained by labor has increased nearly one per cent. labor obtaining in 1880 62·3 per cent. of the selling price of the product, as against 61·6 per cent in 1870. In other words, the cost of labor per ton has not fallen in quite so large a ratio as the value per ton, though both have fallen more than gold did in the same interval.

The following data are given concerning the production of bituminous coal and lignite west of the 100th meridian, including California, Colorado, Montana, Oregon, Washington Territory, and Wyoming, during the census year:

Number of establishments	46
Maximum capacity of yearly production, tons,	2,001,697
Total product, tons of 2,000 lb.	1,477,736
Value of total product	$3,272,470
Value of materials used	$189,431
Wages paid to all classes	$1,828,401
Men employed above ground	621
Men employed below ground	2,812
Total employes	3,441
Number of steam-engines	42
Horse-power of engines	1,447
Value of all machinery	$265,650
Value of explosives used	$26,702
Amount employed as working capital	$369,931
Value of plant	$1,251,442
Value of real estate	$6,858,300
Total capital employed and invested	$8,479,573
Acres of coal land	33,001

—*Coal.*

PRESERVATION OF GOODS FROM MOTHS.

SINCE the remotest times, numberless remedies against insects which attack wool, leathers, silk, etc., have been recommended and tried, but without, apparently, any satisfactory result being yet arrived at. Many of the substances recommended are so poisonous that it is not safe to use them in the house as preservatives against the ravages of moths and insects; others, again, are ineffectual, and only lead to costly disappointments. The greatest enemies of skins and woolen and silk stuffs are moths, and the damage caused by these insects amounts yearly to a good round sum.

The insects which are capable of destroying or damaging the above-mentioned stuffs belong to several different species, and are all-night insects. In classifying these insects, a small moth whose wings are covered with black spots and stripes may be first mentioned. It inhabits the interior of houses, and is found mostly on the walls. The larva of this insect is of a dark-brown color, and smooth, and lives almost entirely upon fatty substances. Réaumur called it the leather moth, because it attacks leather as well as the binding of books. This larva makes for itself a long case, or covering, which it attaches to the object on which it lives. Linnæus remarked, and it has been confirmed by celebrated surgeons, that they are often found in the human stomach, where they give rise to serious disorders. This species is not so widely distributed as some of the others.

Réaumur's wax moth is a small ash-gray insect, with a bright colored head and thorax. The inner edge of the upper wings is spotted with brown. Its length is about five lines. The larva of this moth commits great havoc among the bee-hives, boring itself a way into the honeycomb, and constructing a silken tunnel in the passage through which it passes.

The carpet moth has black upper wings, the under ones being white round the edges; the head is also white. The larva feeds on cloth and thick woolen stuffs, and from the particles of the material it builds a kind of cell, which is continually getting longer as it goes.

The cloth moth is silver-gray, with a white spot on each side of the thorax. The larva is found on cloth and woolen stuffs. It makes a case, or a tunnel, out of its own silk, which serves as its dwelling, and which is strengthened by particles of the stuff to which it is attached. It makes this case longer and broader according to the progress of its own development.

The yellow moth has a head of fawny-yellow color; the front wings are ash-gray, and the hinder ones white. This moth is found principally in stores of provisions and natural products.

The grain moth has a yellowish white head, covered with long hair; its front wings are gray, marbled with brown and black. This moth is ruination itself for grain stores.

The fur or skin moth is a little insect with silver-gray wings, containing one or two spots. This moth is worthy the serious attention of dealers in furs and skins, because, under certain circumstances, it can cause enormous havoc. It lives almost exclusively on the skins, nips the hair off close to the roots, and pierces through the skin itself in countless places. From the particles of the skin it builds itself a tunnel, which serves it for a habitation. This tunnel is a masterpiece in itself, for, as soon as it is born, the larva commences its construction, and is able to widen and lengthen it with particles nipped from the skin for the purpose, and as these particles do not possess the requisite softness, the larva lines it with its own silk. This dwelling is always of the same color as the material from which it is made, and what is most wonderful, the process of digestion which it undergoes does not change the color of the stuff. These larvæ make journeys, too. They leave their dwellings periodically, in order to extend their ravages further, and return, later on, to their old habitations. When they become tired of their devastating exertions, they secure themselves with silken threads of their own production, and remain quiescent in a kind of sleep.

All these moths are, as already mentioned, night-insects, they especially seek out semi-dark places in which to lay their eggs. These eggs are so small as to be imperceivable, and, consequently, woolen stuffs, furs, etc., which, when packed up, were believed to be free from moth, are, when examined later on, often found to be completely eaten up.

The preservatives which have been used up to the present, are of very different kinds. Some are only calculated to keep the moths at a distance, and thus to prevent them from laying their eggs on the stuff to be preserved. To this class of remedies belong many aromatic, or otherwise sharp-smelling substances, such as camphor, pepper, carbolic acid, naphtha, etc.; but none of these is capable of killing the eggs already laid, or the larvæ developed from them. Some other substances, on the other hand, have not the slightest influence on the laying of the eggs, because they are void of smell, and, for the most part, tasteless. Nevertheless, they can poison and kill the larvæ when just born, if the latter happen to be on a spot where some of the poison has fallen. If, however, that is not the case, the larva grows and feeds upon the stuff, until it lights upon a spot where the poison is found. To this category belong arsenic, shaving-powder, various mixtures of soap, potash, and alum, mixtures of alum, arsenic, salt, etc.

All these remedies possess some good and useful points, but their practical effect is not complete and satisfactory; many also have the disadvantage of being poisonous. It is not to be denied, however, that on the principle that prevention is better than cure, those substances which hinder the laying of the eggs are to be preferred. In this respect it is only the odorous substances which take effect on the moths, and of these we have but a limited choice. Coal tar, which contains the germ of the most splendid dyes, must also provide the means to protect from the ravages of the moth the woolen and silken stuffs which have been dyed by its agency, and the furs and skins which attract that insect's attention.

Naphtha is a constituent of coal-tar, of a pungent but unpleasant odor. It volatilizes but slowly, whereby it compares favorably with the very volatile carbolic acid. The effect of naphtha vapor, too, at least when used in the customary small quantities, is not injurious to health. This substance is perfectly neutral, and has no effect upon the stuff or upon the skins on which it is sprinkled, and it is probably to be preferred before all the other preservatives which are used or recommended. Three exhibitors in the Leather and Bark Exhibition, at Berlin, exposed preservative substances made from naphtha. Two of them from Germany—viz., Arno Henny, of Attenburg, and O. Meissner, of Leipsic—exhibited their preparations under the name of "antiputrin;" the other, W. Neuber, of Vienna, showed the same kind of thing under the more rational name of "antitineïn." A German paper, commenting on these substances, says: "The active principle of these three preparations is naphtha. The antiputrin has this advantage over carbolic acid, that it does not injure the wool or skin, which cannot be said absolutely of carbolic acid. Besides, the best use is made of carbolic acid when the materials to be preserved are brought into a close space and *steamed* with pure carbolic acid. By this means insects, larvæ, eggs, and all, are destroyed, but the effect is only ephemeral, and only preserves while the operation lasts."—*Hatters' Gazette.*

STORAGE OF ELECTRICITY.

AT a recent meeting of the Newcastle-upon-Tyne Chemical Society, Mr. J. W. Swan read the following paper on "Voltaic Accumulation." We owe the term "voltaic accumulation" to M. Planté; we owe the idea of "voltaic accumulation" to him also. But more than this, we owe to Planté the rich results of a life devoted almost entirely to researches in connection with this subject. M. Planté employs the phrase "voltaic accumulation" in a double sense—to signify storage, and to signify cumulative effect. It is in this last sense that the term is generally used by M. Planté, and it is to voltaic accumulation in this sense that M. Planté has chiefly directed his attention. One of his principal aims has been to produce by means of voltaic accumulation the high tension effects usually obtained from the frictional electrical machine. At no very distant period the phenomena of voltaic electricity and of frictional electricity were so widely different, that a strong effort of the imagination and a clear perception of the laws governing these phenomena were necessary in order to be able to entertain the belief that the agency which, led by naked wires, operated so quietly in causing the deposition of copper in large quantity from copper solution, could be the same which, bursting all bounds, rushed with flash and detonation to its goal.

When the platinum terminals of a voltaic battery composed of a few cells are made to dip in acid water, gas in torrents pours upward from them. If the same platinum poles, dipping in the same acid solution, be disconnected from the quietly but powerfully working battery, and put in connection with the prime conductor and the cushion of a large electrical machine of the frictional type, you may turn the handle by the hour and produce an amount of electricity that would maintain a continuous stream of fire, and yet not a single bubble of gas will rise from the platinum poles. Moreover, the voltaic cells which decomposed the water so rapidly would give no shock, nor the tiniest spark through the smallest measurable space of air; while the chemically ineffective electrical machine would rack your limbs terribly and dart its spark through several inches of hair.

At a very early period of the history of the voltaic battery it was known that by largely multiplying the series of cells, both sparks and shocks could be obtained from the terminal conductors; and on the other hand it was found that, by employing electrical machines of great power and forming poles of fine platinum wire coated with glass to the end, so as to reduce to almost a point the exposed surface of the platinum, water could be slowly decomposed.

In later years the two classes of phenomena characteristic of the voltaic battery and the electrical machine have made considerable advances toward each other. De la Rue has constructed a battery of thirty thousand of his zinc and silver couple capable of producing a discharge through one-third of an inch of air; capable also of illuminating long vacuum

tubes and of producing other effects of high electric tension. At the Paris electrical exhibition I saw an electrical machine on the Holtz principle, composed of thirty glass plates of small diameter, which was capable of decomposing water freely and of maintaining a thin platinum wire white hot as long as the plates were kept revolving. These approaches to identity of effect, by the electricity of voltaic action, of friction, and of induction, are of recent date. Before these results had been obtained, M. Planté, by means of methods the most ingenious and experiments the most striking, completely bridged the gulf that separates the phenomena of high tension and low tension electricity. M. Planté has achieved this result by means of secondary voltaic action.

The charging and re-charging of a series of thirty thousand cells must evidently be an extremely troublesome operation. M. Planté avoids this trouble by making a few cells (two are sufficient) do the work of charging any number of secondary cells, which, after being charged, are joined in series and made to develop high tension effects. This is chiefly the kind of accumulation performed by M. Planté by means of his secondary cell, namely, the accumulation of tension or electromotive force. Here is a Planté cell. It consists of two plates of lead rolled together but separated by narrow strips of gutta percha. These two lead plates being, to begin with, in the same condition, generate no current when immersed in dilute acid and united through the wire of a galvanometer. But if the couple be for a time connected, the one plate with the anode and the other with the cathode of a voltaic cell, or any other form of electrical generator capable of developing an electromotive force of not less than three volts, the anode plate becomes coated with peroxide of lead. If then the secondary cell be detached from the primary cells it will be found to be capable of generating a powerful current of about one fifth more electromotive force than Grove's cell. When it is desired to obtain cumulative effects from a series of Planté's cells, a mechanical arrangement is made whereby the plates of the different cells are so connected together that they are in effect one couple; that is to say, all the inner plates are connected together as one plate. Arranged in this manner, if one of the poles of two Grove cells, coupled in series, be connected with the terminal which is common to all the inner plates, and the other pole be connected to the terminal common to all the outer plates, the same change takes place in the one hundred, or it may be the one thousand cells as that which takes place in charging a single cell. That is to say: if all the outer plates were connected with the *positive* pole of the Grove's cell, all these plates would be oxidized, and in this condition all the cells may be said to be charged just as a Grove cell is charged when one puts the nitric acid into it; for the highly oxidized lead of a Planté cell plays exactly the same part as the nitric acid of a Grove cell, and it is only necessary to alter the connection of one cell with another, so as to connect them in series, in order to obtain from them the cumulative electromotive effect due to their number.

Planté has devised a convenient method of making this change in the connections. This apparatus illustrates the arrangement.

The cells are arranged in line with a spring projecting upward from each plate on each side of the line; between these two lines of springs an axle of ebonite runs, with metal bands so inlaid upon it, that when it is in *one* position all the springs on one side are pressing against a long strip of copper on that side and all the other springs on a corresponding long strip of copper on the other side. In this position the cells are arranged for charging, the two long strips of copper being the two poles. When charging has been effected it suffices to turn the ebonite bar on its axis through a quarter of a circle in order to disconnect the springs from the two long strips of metal mentioned, and to bring them into contact with short strips of copper inlaid and insulated in the bar and crossing it obliquely so as to put the oxidized or positive plate of one cell in metallic communication with the non-oxidized plate of the next cell throughout the entire series. The change of connections is the work of a moment, and the result is a multiplication of the electromotive force by the number of cells.

I saw at M. Planté's house, which is also his laboratory, eight hundred cells arranged in this way, all charged from two Bunsen cells, which were placed outside the room on the window sill. By means of these eight hundred cells, worked in this convenient manner without the slightest annoyance from fumes or acids, the effects of about nine hundred Grove cells were obtained.

[Mr. Swan here illustrated the working of the apparatus by means of a battery of twenty small Faure cells arranged in a Planté commutating trough. When connected parallel, a copper wire was heated to whiteness and melted, and when in series, a Swan lamp was brilliantly illuminated.]

M. Planté went a step beyond this. He charged a large series of plates of mica, partly coated on each side with tin foil, on the principle of the Leyden jar. These were connected in charging and in discharging in the same manner as the secondary battery, that is, all the coatings of tin foil turned one way were connected together, and all the coatings turned the other way were connected together. When, by the momentary joining of these two groups of plate coatings to the two poles of eight hundred secondary cells, plates became charged, the connections were then changed from quantity to tension. By this contrivance the electromotive force of the four volts, due to the two primary Grove cells, was accumulated first to eighteen hundred volts, and this again was increased fifty fold by the mica plates. I can bear witness to the fact that it was sufficient to produce flashing discharges some inches in length, exactly resembling the discharges of a frictional electrical machine.

That is electrical accumulation in one sense, but there is another sense in which the phrase has been much used of late in connection with Faure's accumulator, namely, in the sense of storage. Planté's cell, with slight modifications, lends itself most perfectly to voltaic accumulation in the sense of storage. The very essence of the idea of storage is retentivity. The cell to act as a reservoir, or store, must be retentive of the charge communicated to it. This is a quality possessed in an eminent degree by the Planté cell. There is, comparatively with other voltaic cells, which, but for the want of retentivity, might be employed for electrical storage, very little loss of charge by lapse of time within the limit of a few hours. But for the defect of loss of charge by local action—that is, chemical action not utilizable in the production of electric current, the zinc and copper cell of Daniell and several other well-known voltaic combinations, not usually regarded as susceptible of being used as secondary cells, might have been employed for electrical storage.

Perhaps the ideal of a cell for storage is Grove's gas cell. Here is a specimen of it: it consists of two gas tubes, and two plates of platinized platinum immersed in dilute sulphuric acid. If while the tubes are filled with dilute acid, one plate is connected with the positive and the other with the negative pole of a voltaic battery, the one tube becomes filled with oxygen and the other with hydrogen, and when so filled the cell is an electric store, capable, even after the lapse of a long time, of yielding a current.

But Grove's cell is quite out of the question for large operations, if only because platinum is so scarce. Theoretically it would perhaps be improved by making the hydrogen pole of palladium instead of platinum, so as to obtain the advantage of greater condensation of the hydrogen, and thus to reduce the resistance by increasing the extent of the contact between the gases, the pole plates, and the acidified water. Dr. C. W. Siemens communicated to the York Meeting of the British Association some interesting experiments in the employment of plates of carbon, both simple and platinized, as substitutes for platinum plates in the construction of a gas battery. The porosity of the carbon plates was utilized so as to bring the poles close together and greatly reduce resistance. The results obtained were well worthy of publication, although they did not quite reach the point aimed at, namely, practical utility for the electrical storage of energy.

I had imagined that De la Rue's cell, composed of zinc and silver incrusted with chloride of silver, might probably be employed in certain exceptional cases for electrical storage. On mentioning this very obvious idea to Dr. De la Rue, he told me there was a difficulty in the way, arising out of the tendency to the formation of oxychloride instead of chloride of silver.

For electrical storage on any large scale we look in vain to discover a better material than that fixed upon after infinite painstaking by M. Planté. Planté cell, pure and simple, is a most admirable electrical accumulator in the storage sense of the word. It has one drawback, however: it requires a considerable time to give to the lead plates a large storage capacity. M. Planté's method of preparing his cell is as follows:

"The secondary cell is first filled with water acidulated with sulphuric acid (one quart acid to ten quarts of water), and on the first day it is charged by the current from two Bunsen cells six or eight times, the direction of the primary current being changed at each new charge. The secondary cell is discharged between each reversal of the direction, and it is ascertained either by heating a piece of platinum wire to incandescence, or by other suitable means, that the duration of the secondary current continually increases after each charge.

"The time during which the secondary couple is submitted to the action of the primary current in the same direction is increased little by little.

"Thus, on the first day, the period is increased from a quarter of an hour to half an hour and one hour, and, finally, the battery is left over night in the process of charging. The next day it is discharged and then recharged for two hours in the opposite direction, then again in the previous one, and so on. But soon a limit is reached beyond which the duration of the secondary current is not found sensibly to increase, especially when the primary cells, not having been removed, have grown by these successive actions little by little weaker, and have no longer sufficient intensity to cause the electrolysis to penetrate deeper into the interior of the lead plates.

"The secondary couple is then left at rest for eight days, and at the end of that time is recharged in the opposite direction for several hours continuously, without making on that day a fresh alteration in the direction of the primary current.

"Then the interval of rest is extended little by little to a fortnight, one month, two months, etc., and the duration of the discharge is found to go on continually increasing. It has, in fact, no other limit than the thickness of the lead plates. The positive plate, if it is thin, finishes by being almost entirely transformed by time into peroxide of lead of a crystalline texture; and the negative plate becomes formed by degrees, to a certain depth below its surface, of reduced lead of a granular and crystalline nature.

"It is not always necessary to push the electro chemical preparations of secondary couples as far as this complete transformation of the physical and chemical nature of the plates, for the couples would ultimately acquire a much greater resistance and take more time to charge them.

"When the couples yield a current of sufficient duration for the purposes for which one wants them, it is no longer necessary to change the direction of the primary current each time the cells are charged. The quantity of peroxide of lead accumulated upon the positive plate would take too long to reduce, and no result would be got from the couple before several hours. A definite direction is therefore adopted, in which the secondary cells, when once sufficiently 'formed,' are always charged."

It is evidently desirable—more especially in view of the want more and more urgently felt as time goes on, of an accumulator which will be available for the large and important uses to which electricity will in future time be put—if possible, to avoid this tedious process of preparation so minutely described by M. Planté. No doubt it answers the purpose quite well when industrial applications are not in the question, but for electrical accumulators, such as must be used in connection with a central system of electric lighting, and which would probably involve the use of a set of large cells in every house, this slow process of preparation would be hardly applicable. It was with a desire to avoid this disadvantage and give to Planté's cells a greater capacity of storage, that I made the experiments last winter, the outcome of which was the modification of Planté's cell, which I showed you at our February meeting. Here are some of the cells I then exhibited in action. The idea of this modification was to increase the surface of the lead by means of lead foil, crimped and formed into frills, the interstices between the frillings being filled with electrolytically deposited spongy lead. The same idea has been applied in a somewhat different way by M. Faure in his accumulator. In M. Faure's accumulator, red lead mixed with dilute sulphuric acid is plastered on lead plates; the coated plates are wrapped in felt, and either rolled up like the plates of a Planté's cell, or doubled together and placed in rectangular lead-lined wooden boxes. These cells have been made on a large scale, and for this reason, and because the application of the red-lead coating greatly favors the obtaining of storage capacity, effects have been obtained from them clearly pointing to practical use in electric lighting, and perhaps also for other purposes. The cell has, of course, the same electromotive force as the Planté cell, of which it is a modification; being large, it has, when fully charged, a small resistance, and is on that account capable of producing astonishing effects in the way of heating thick wire [heats some wire]. Thirty of these cells, weighing about fifty pounds each, when properly charged, will keep twenty of my lamps up to twenty candle power for several hours.

M. de Meritens has also made an accumulator on the Planté lines. The Meritens accumulator consists simply of plates built up of lead foil. Here is a representation of one of his plates shown in section. I have not any accurate information of the working of De Meritens' cell.

I have recently introduced into the construction of the Planté cell some modifications which, I anticipate, will increase its utility when applied on a large scale for the practical work of storage for electric lighting. One of my innovations consists in making the lead plates corrugated or cellular, the cells or grooves being filled with spongy lead, which from the form of the plate will remain attached to it without any external wrapping of felt or similar material being necessary. The felt in the Faure cell must, I imagine, be in a short space of time destroyed by the action of the acid, and occasion displacement of the material applied to the surface of the plate and held in its position by it. I have heard that it is proposed to substitute asbestos cloth for the felt—this, no doubt, will remedy the defect I have mentioned, but it must greatly increase the cost of constructing the cell. It is obviously desirable to avoid the use of any extraneous material, and the use of grooves or cellular plates accomplishes this object. I have made other improvements for the means of obtaining electrical storage; details of which I must, for the present, hold in reserve, but with the hope at some future time of bringing them under the notice of the society.

A NOVEL ELECTRIC MOTOR.

As well known, the electric motors which do the most effective work are those whose magnetic masses submitted to reversals of polarity are as greatly reduced as possible, or those whose reversals of polarity are effected, as in the Gramme ring, in a continuous manner by a regular displacement of the poles upon the ring.

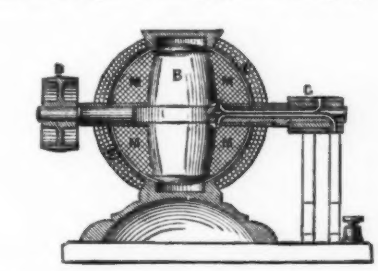


FIG. 1.—LONGITUDINAL SECTION.

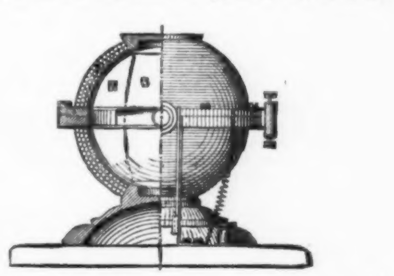


FIG. 2.—END VIEW AND TRANSVERSE SECTION.

At the recent exhibition of electricity at Paris, Mr Bürgin, of Bâle, exhibited a small motor in which there were no magnetic masses at all submitted to reversals of polarity. There was thus no magnetic inertia to be overcome, and the motor so constructed was able to revolve at high speeds. The model exhibited was simple and compact and greatly puzzled visitors, who could not understand how the motion was produced.

The accompanying figures will readily permit the principal arrangements of the apparatus to be understood.

It consists of an iron core, B (Figs. 1 and 2), surrounded by wire, M, whose spirals are wound to complete a sphere. This iron core revolves around a horizontal axis; and the wires, M, connected with the shells of a commutator, C, are traversed by a continuous current coming from the source (either a pile or dynamo-electric machine), and polarize the extremities of the core, B, without reversing the polarities, in spite of the rotation of the core.

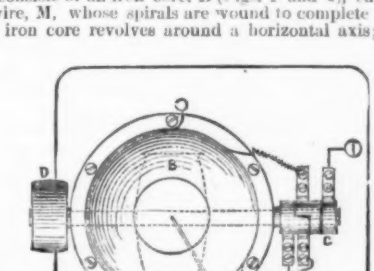


FIG. 3.—PLAN.

The sphere formed by the core and the wire, M, revolves in the interior of a second hollow fixed sphere, around which is wound horizontally a second continuous wire, E, connected with the two brushes of the commutator, C.

As a consequence of the reciprocal reactions exerted between the wires of the fixed spherical shell and the movable polarized core, B, in its interior, and as a consequence of the reversals of current that take place in the said shell, the core and its axis assume a rapid rotary motion.

This motor is characterized by the following features:

1. The movable part is formed of an electro-magnet whose polarities are never reversed;

2. The currents are reversed in the fixed part of the motor and not in the movable;

3. The movements are produced by the reciprocal action of a current and of an electro-magnet, and not by the mutual attractions of two electro-magnets.

Owing to this arrangement, then, we have no magnetic inertia to overcome, since the system operates without any reversal of the polarity of the core. It would prove of interest to make some measurements of this little motor's performance in order to ascertain whether, as might be believed *a priori*, its effective work would prove superior to that of a double T Siemens bobbin.

ELECTRICAL CONDUCTORS.

Within the past ten years the great increase of business in the country and corresponding demand for modes and means of telegraphic and telephonic communication, to say nothing of the large interests invested in electric lighting systems, have put inventors upon their inquiry as to the best modes of providing underground conductors for electric currents, upon which all depend for a motive power. It was known to Faraday, to Morse, and our late but no less distinguished countryman, Prof. Henry, many years ago, when the telegraph was yet in its infancy, that underground cables, so far as telegraphic purposes were concerned, were not a success for distances of over ten miles, in view of the increased inductive effects as the length of the line increased, the proportion being inversely as the square of its length, so that if we represent the inductive effects of a cable one mile long by five, the effects on a cable of similar nature two miles long would be twenty-five. Thus we easily perceive a limit is soon reached where cables become useless. These troubles have become much more annoying in our telephone system, owing to the extreme delicacy of the instruments. In fact, so delicate are they that the familiar ticking of Morse instruments upon parallel lines thirty or forty feet away are perfectly intelligible to one listening at the receiver, even during the time conversations are being held. Let us inquire, then: 1st. What is induction? 2d. How does it act under varying circumstances? and 3d. What modes have been devised for overcoming it, and how far are they successful? Induction may be briefly defined as a force transmitted through space without the agency of any intervening material medium, as for instance, if we hold the north pole of a magnet over the like pole of an ordinary compass needle, the latter is repelled, and if the same pole is held near the south pole of the needle, it in turn is attracted. This manifestation on the part of the needle to move is the result of an inductive power inherent in both the needle and the near pole, and both are similarly affected, but in varying proportions dependent upon their relative dimensions, distances, etc.

So if electric currents are passing over two wires in the immediate neighborhood of each other, they exert a mutual attraction or repulsion dependent on their strength, their direction, their distance apart, and their conductivity. If the wires are parallel and the currents running in the same direction, their tendency is to be attracted; if in diverse directions, to be repulsed; and if at an angle, the same respectively as in the above instances, but proportionate always to the cosine of their angle of inclination. So that if they cross each other at right angles the effect is nil.

The resistance of a conductor varies directly as its length, and inversely as its sectional area. So that a conductor two miles long of one square inch cross section will have the same resistance as a conductor one mile long of one-half of a square inch cross section. Electrical induction may be said to act by way of radiation, somewhat as a hot wire gives off its heat, that is, inversely as the square of the distance. So that from every point of the wire an invisible force is exerted in the line of a secant from the axial center of the wire. If, then, two wires of like size and length are placed side by side and joined at one end, and a current of electricity passed through them from a battery, there results this radiation from the center of each, in lines of secants; and if we suppose the two wires to be perfect cylinders throughout their entire length, and with their axes absolutely parallel, there are two elements of induction, one on each cylinder, which coincide, or in other words, there is a line of antagonistic forces, the effects of which upon each other vary inversely as the square of the distance between centers of said cylinders, provided the wires are saturated to their carrying capacities and are absolutely similar in their conducting capacities throughout.

These two forces must then nullify each other, or in other words inasmuch as they are opposite in polarity, they absorb each other, and there results a total inductive effect due to the remaining axial lines upon each other, there being a magnetic field of 90° on each side of the coinciding lines which is subject to the disturbing influences. So that each wire is not only exercising a diminished inductive effect upon the other through the remaining lines of radiation, but is subject to surrounding influences. This plan has been adopted in telephonic systems, the two wires being insulated and constituting the complete telephonic circuit. A much more effective plan would be to surround one insulated conductor with a series of smaller parallel insulated conductors, theoretically an infinite number, but having an electrical resistance whose sum total was equal to that of the central wire. In this way each tangential line of radiation of the central wire will find a corresponding tangential element of induction in a parallel conductor. A cylindrical metallic coating has been suggested, whose resistance equals that of the central conductor, but I doubt if it would be as effective as the method of innumerable parallel insulated wires, as above suggested, all being united at the extremities to the transmitter's battery and receivers.

It has also been proposed to twist the insulated wires together, and this is somewhat more effectual, but if closely examined will show that there must result a spiral tangential line similar to the construction when arranged parallel as above described. Another method has been devised which is replete in its ingenuity, and, under recent experiments, has proven quite a success.

An insulated conductor of given resistance is wound with another insulated wire as nearly at right angles as possible, but having such a sectional area that its electrical resistance equals that of the central wire. Here we have the two currents crossing each other at right angles, so that no influence can be felt aside from that which results in the spiral conductor due to the coils one upon another, which experience proves to be practically nil. But of course it is not possible to wind one wire absolutely at right angles upon another, hence there must result an inductive effect proportional to the cosine of the angle of inclination of the two wires, which in a long cable would amount to considerable if we account for the horizontal components due to this difference; but this trouble is overcome by reversing the conductors, that is, by making the cable in links of several miles in length in which the axial and solenoidal conductors change their relative positions.

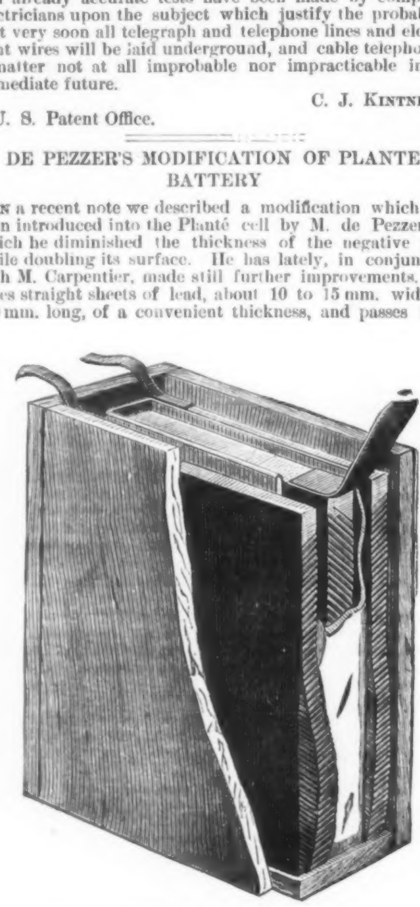
Theoretically the number of these sections would have to be infinite, but its practical working is a matter of no doubt, and already accurate tests have been made by competent electricians upon the subject which justify the probability that very soon all telegraph and telephone lines and electric light wires will be laid underground, and cable telephony is a matter not at all improbable nor impracticable in the immediate future.

C. J. Kintner.

U. S. Patent Office.

DE PEZZER'S MODIFICATION OF PLANTE'S BATTERY

In a recent note we described a modification which had been introduced into the Planté cell by M. de Pezzer, by which he diminished the thickness of the negative plate while doubling its surface. He has lately, in conjunction with M. Carpentier, made still further improvements. He takes straight sheets of lead, about 10 to 15 mm. wide, by 500 mm. long, of a convenient thickness, and passes them



IMPROVED PLANTE BATTERY.

between the rollers of an obliquely corrugating machine. Each sheet is folded in two, the parts being separated by a porous separator. The free ends are soldered together, and fringes are thus formed as shown in the figure. These fringes are introduced in place of the carbon and zinc, in a Bunsen cell, of the rectangular Ruhmkorff kind; they fill up the porous jar and the intervals between the porous jar and the sides of the outer jar. The two jars are also filled with water and sulphuric acid. The soldered ends are at the top, the folds at the bottom; projecting plates fixed to the upper parts serve as electrodes, the positive in the interior, the negative outside. In this way the negative electrode has a surface double that of the positive.

The positive threads are 0·5 mm. thick and 15 wide; the negative threads are 0·25 mm. thick and 10 wide. The waves of each thread make with its edges an angle of 45; after being folded, the inclination of the troughs is alternated on the two halves brought into contact. This arrangement maintains and limits the distance between neighboring parts. The canals, whose existence is thus protected, assure the electrolytic action on all points, and their inclination guarantees the giving off of gases directly they begin to form.

MM. Pezzer and Carpentier construct their apparatus in troughs with two compartments. This arrangement is shown in the figure, but with four instead of two compartments.

Although the porous jar may seem to be inconvenient, the inventors have found that the resistance of their couple is not greater than that of other known accumulators. Moreover, there is a *raison d'être* for the porous jar. Secondary batteries in constant use are subject to crystallized junctions between the plates, which are a source of trouble. Felt, cloth, and amianthus prevent these junctions if they do not encourage parasitic growths by furnishing them with a refuge, a development against which they are powerless. The walls of burnt earth act in a directly inverse manner; thus the partition causes to be retained on the plates, or in the field of their action, the particles of oxide detached and carried off by gravity.

This arrangement of the secondary battery is said to have given good results.—*The Electrician.*

WATER POWER FOR FARMS.

The most perfect system of farm machinery driven by water power, which we have had an opportunity for examining, is on the Geddes farm, in Onondaga County, N. Y., constructed by George Geddes, James Geddes, his son, and George, his grandson, who all inherit a liberal share of engineering talent. A brook or small stream, crossing the farm and having sixteen feet fall, has been made to grind feed with a pair of burr-stones, to cut cornstalks, drive a lathe, slice roots, shell corn, turn grindstone, churn butter, and it may be made to perform any work which is done with

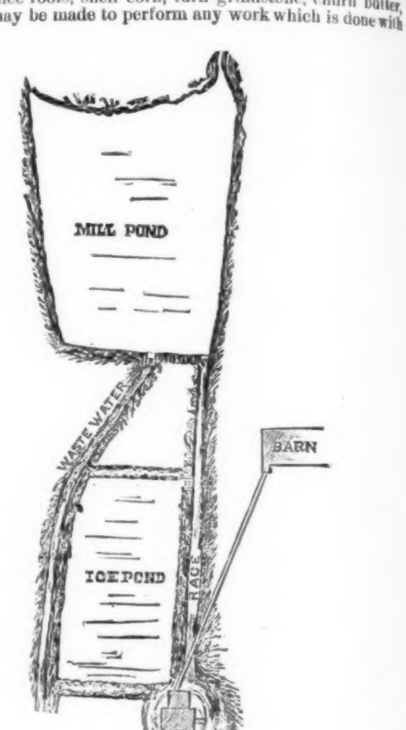


Fig. 1.—MAP OF PONDS AND POSITION OF BUILDINGS.

stationary power. The stream of water thus turned to valuable account was sufficently large, at the time we examined it this winter (about its usual size at this time of the year), to afford 60 gallons a second (besides some escaping by the waste-weir), and to turn a 12-foot overshot wheel of ten or eleven horse power. From personal examination we found the mill would grind 20 bushels an hour of a mixture of two parts of oats and one of corn, and of oats alone 25 bushels an hour. With clear corn the amount would probably be from 12 to 14 bushels. The grinding was very thoroughly done. The cornstalks were cut as fast as a man could feed the cutter, as they require comparatively little power; and the corn sheller turned out 30 bushels an hour, or as fast as it could be fed. This power has not yet been applied to thrashing grain, which it would doubtless perform with great efficiency, equal to a ten-horse engine.

A very striking advantage which such water-power possesses for the purpose to which it is applied, is that it is always ready for work at any moment, costs nothing, or requires no attendant to keep it running. Unlike horse-power, no preparatory harnessing is needed, or any driver to keep the team moving; and it never tires. No fuel or attending engineer is necessary, as with the steam engine. All that the manager has to do, to bring any portion of the machinery into play, is to adjust the bands or gearing and pull a lever, the work of a few seconds only, when any part is put to its work without the aid of an assistant.

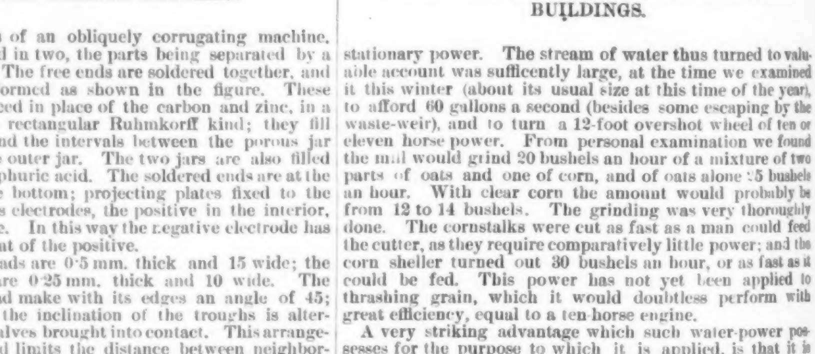


Fig. 2.—VIEW OF PONDS AND BUILDINGS.

The accompanying map (Fig. 1) will serve to explain to the reader the position of the stream, of the ponds, and of the buildings, without giving the accurate dimensions. The portion marked "mill pond" contains about two acres, the water from which is turned by means of a gate into the "race," through which it passes to the lower building, which is 21 by 30 feet, and contains most of the machinery. The water-wheel occupies a wing of this building. The "barn" stands on a hill over 200 feet distant, and 60 feet higher, containing the stalk-cutter and root-slicer, which are driven by an endless rope running from the water-wheel. A wire

at the barn enables the attendant or manager to open the water-gate on the wheel by merely pulling a lever. The lower pond, marked "ice-pond" has no connection with the machinery, and is filled through its gate at the upper end, from the race. Special pains are taken that none but pure and clear water passes into it.

Thick ice is prevented from forming in the mill-pond, and from obstructing the current, as the water is drawn off during the day, the pond being filled in the night by the run of the brook. The opening and closing of the water-gate for this purpose is readily performed by means of a wire or small rod 700 feet long, reaching from the mill to the pond, which raises the gate, the wire holding it open until it is closed by its own weight.

Fig. 2 is a perspective view, taken from the lower side of the ground, and from a point part way up the hill, showing the machinery building, the two ponds, and the barn on the hill, with the endless rope which conveys the power from one building to the other, and the wire for opening the gate on the water-wheel.*

The arrangement by which the connection is made from the water-wheel to the barn on the hill, through the endless rope, is ingenious and admirable. To prevent a variation

mill. The burr-stones are 18 inches in diameter, have a horizontal axis, and are cased in iron. They make from 700 to 900 revolutions in a minute. They cost $100. The meal is either bagged in the basement, by suspending each bag to the lower end of the tube through which the meal is discharged from the stones; or, more commonly, is taken by an ordinary elevator to the side of the car (in the upper story) which brings the grain to the mill. There it is bagged, loaded on the car, and rolled out to the side of the wagon which brought it, to convey away. One man may lift and handle the burr-stones, and dress them at his pleasure; and the facilities connected with the building are such that he works alone without any assistant in performing any part of the work.

The water-wheel is 12 feet in diameter, with buckets 4 feet long. As there is nearly always a surplus of water, it is allowed to run 6 feet per second, that being the velocity of the current of water as it is discharged upon the wheel With less water it may run slower. The buckets have each three auger holes of one inch each, near the bottom, for the admission of air to allow the free and ready reception of the water, or its discharge at the bottom of the revolution. The overshot wheel is better for the purpose in several respects

ble of retaining a portion of the heat, which may from some cause be found beneath them. They also freely admit the light of the sun and thus assist the young plants in their healthy development. None of our common agricultural plants could long remain healthy in a totally dark atmosphere.

Growing plants must have sunlight, and it is to afford them light that we cover our frames with glass, instead of tin or boards, which would shut out the sun's rays. Glass is not a perfect conductor of light, but it is the best of anything we have. A half dozen thicknesses of ordinary window glass will cast quite a shadow. Of heat, glass is a poor conductor, as many of us have learned to our sorrow when using it for bottling fruit. Could copper be rendered as transparent as glass, it would still be unfit for hot-beds because of the freedom with which it conducts away heat.

PHILOSOPHY OF HEAT.

In sunny weather, the soil in a hot-bed absorbs a great amount of heat from the sun, and if the frame is tight and the sash well fitted to it, the heat will be largely retained, but as glass is not a perfect non-conductor of heat it will gradually let it pass out into the open air. To prevent this

FIG. 3.—TIGHTENER.

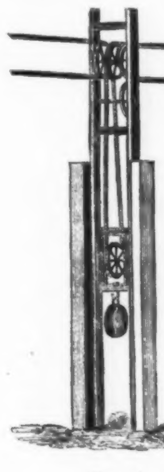


FIG. 4.

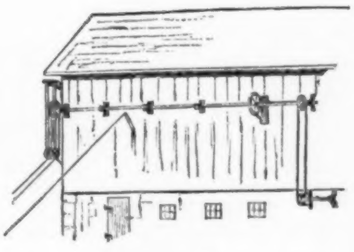


FIG. 5.—CONNECTION WITH BARN.

FIG. 6.

in the tension of the rope in wet or dry weather, or from other causes, a tightener is placed in the middle, which consists essentially of a hanging loop in the rope running over wheels, and from the lower part of the loop a weight is hung, which always keeps the rope at the same degree of tension Fig. 3 represents this contrivance with the frame omitted. One of the ropes, in the first place, passes over a wheel, then down around a wheel in a frame which moves up and down, then up and around another wheel alongside the first, and then onward. A weight of 250 pounds is hung to the movable frame, and when the rope is wet and shortened by dampness the weight rises, and when lengthened by dry weather the weight descends. The other rope merely passes between the outer grooves of two other wheels to keep it in place. Fig. 4 is a view of the supporting frame.

Fig 5 shows the connection with the barn on the hill, at the left corner. As the barn does not face the mill-building at right angles, but stands obliquely to it, a special arrangement is made for meeting this difficulty, by working the horizontal shaft on the outside of the barn. One of the ropes passes around a wheel standing in a line with these ropes; then up and around a larger wheel on the horizontal shaft; then down around another wheel, paralled with the first. This contrivance is shown more distinctly in Fig. 6, the supporting frame being omitted. The horizontal shaft, on the barn, has a band-wheel, from which a band passes into the barn to drive the stalk cutter, and another wheel lower down which drives the root slicer in the basement The shaft runs in iron supports with babbitt-boxes, which hold it a foot from the barn, so that in case at any future time it should be neglected in oiling, the friction cannot by generating heat set the barn on fire.

FIG. 7.

FIG. 8.

The lower wheel shown in Fig. 6, and all the wheels in the tightener, are cast from the same pattern, and are sixteen inches in diameter. The upper wheel in Fig. 6, is four feet in diameter. A contrivance like that shown in Fig. 6, is placed at the water-wheel, to give the ropes their oblique direction. The grooves in the exteriors of the wheels were made slightly too large for the rope, so that it rested only on its inner sides, Fig. 7, and grasped the wheel with less friction than if the groove had been so narrow as to press the side of the rope, as in Fig. 8. The rope is manila, seven eighths of an inch in diameter, and as it is used and exposed only in winter, it is expected to last six years, as ropes in manufactories, exposed all the year, last three years Tarred ropes are not adapted to this purpose.

Fig. 9 represents the interior of the mill building. The large hopper to burr-stones holds 160 bushels and the small hopper holds 5 bushels. The three water rams drive a copious supply of water at all times through a buried iron pipe up to the barn, to the dwelling which is seventy feet above, and in summer to the garden and to the lawns and fountains. They discharge 10 gallons per minute.

The water-wheel and the rams, being surrounded with a thick wall in a wing of the main mill building, and largely banked with earth, and the windows being furnished with double sash, frost in the coldest weather is effectually excluded.

In grinding corn, it goes first from the wagon on the roadway over the level track on a small car to the upper story and to the corn-sheller. The cobs are cast outside by the machine, and the grain is passed to the place for mixing with oats, and thence to the hopper. It runs down through a tube, which has a cut-off slide, into the iron hopper of the

* The engraver has represented the appearance of water pouring over the dam, which is not correct, as it is merely an earth bank.

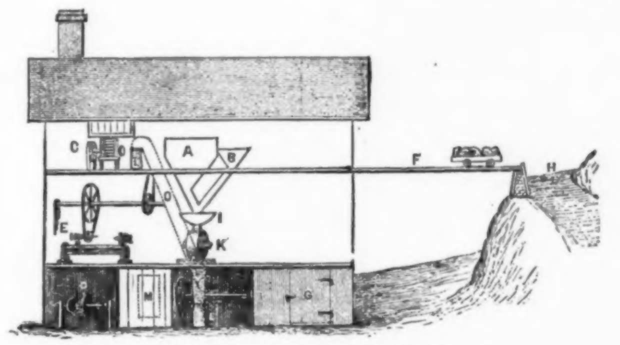
than the turbine wheel, and may be more easily adapted to smaller supplies of water in summer, when it is run for lighter work with one-twentieth its usual supply of water.

It is proper to add that all the machinery is constructed in the most substantial and durable manner, and there is little danger of its becoming deranged by use.

When it is borne in mind that the entire farms with which this machinery is connected comprise between 400 and 500 acres, and that the single item of grinding feed for the animals includes 2,000 bushels annually, its great advantages on the score of economy and convenience are obvious. Formerly, it was necessary to pay five cents a bushel for grinding elsewhere, at a cost of at least five cents more for drawing both ways, making $200 annually for this item alone. As the mill will turn out at least 200 bushels a day, a fair profit is made in grinding for neighbors; and for small grists the small hopper is intended, although custom work was not thought of in the first place. The whole cost of everything was about $1,500.

loss of heat through the glass during the night, when the weather is excessively cold, gardeners cover their glass with thick straw mats, or shutters made of boards, and in some cases with both. But the sun cannot be depended upon for heating the soil of a spring garden under glass. At best, the sun heats the soil to but a little depth, nor is the heat applied where it is most needed. A warm soil for the roots to penetrate and a moderately warm atmosphere, are what plants most delight in. To keep the feet warm and the head cool is a piece of advice applicable both to animals and to plants. Again during cloudy weather and at night, the sun has little or no influence in warming the earth.

A hot-bed means a small garden, protected by glass and a wooden frame, and in some way heated artificially. The heat may be furnished by hot air or water pipes buried in the soil beneath the plants. This is one of the methods adopted when the hot-bed takes the size and form of a hot-house. On some accounts a house is better than a simple bed. The house admits of potting and other work being



INTERIOR OF MILL BUILDING.

A, large hopper; B, small hopper; C, corn-sheller; D, grindstone; E lathe; F, tram-way; G, door to three water rams; H, wagon road; I, iron hopper to burr-stones; K, burr-stones; L, receiving bags; M, position of water-wheel; O, position of elevator shown by dotted lines.

George Geddes writes to us, at a later date: "We are now cutting barley straw (1½ inches long) and mixing it with one-third inch cornstalks. The cows eat the mixture well. A little wheat straw for bedding makes manure just dry enough, and fit to draw and spread on the land." He further adds: "This machinery must lead to our raising more corn, feeding more cattle making more manure, and raising our grain on less acres. So I conclude the money paid out is better invested than it would be at interest."—*Country Gentleman.*

HOW TO MAKE HOT-BEDS.

PERSONS not having experience in making and tending hot-beds for starting early vegetables, are not unfrequently ignorant of some of the first principles necessary to be understood in order to attain success. And first it should be clearly understood that glass, in and of itself, contains no heat and has no heating power whatever. It does not even "draw the sun" or gather any of the sun's heat. A pane of window glass lying on the ground or suspended in the air, will maintain very nearly the same temperature of the surrounding atmosphere. A piece of dark colored slate lying upon the earth exposed to the sun's rays, would be warmer than a plate of glass under the same circumstances. The slate absorbs the rays and is consequently warmed, while the glass will let the rays pass through it into the soil beneath. Glass sashes placed over a hot bed frame are capa-

done during stormy weather, and the heat can be better controlled and renewed, but the house is more costly and the atmosphere is not quite so favorable as in a bed with sashes low down and as flat as they may be and turn water.

MANURE FOR HEATING.

Horse manure is the most common material used in hot-beds to generate and maintain a due amount of heat in the soil. We must remember that it is the soil of the hot-bed that we are particularly anxious to keep warm. If the soil be warm the air will also be warm, provided the frame and sashes are sufficiently tight. The first thing to do in the spring is to get a quantity of horse manure ready for use. Manure from grain fed horses is best, because it will heat more readily. The manure from a horse fed exclusively upon bog hay or dead straw, would make poor material for heating the soil of a hot-bed. Having secured the manure, it must be forked over to let in the air, for plenty of air is necessary to any kind of fermentation. Throw it into a high heap, leaving it as light as possible. When it begins to warm up in the middle, which may be learned by thrusting in a small, smooth stick, it should be shoveled over again, to bring the outside and bottom into a fermenting state. Repeat the throwing over till the whole pile is thoroughly warmed through. Plenty of straw bedding or forest leaves mixed with the manure in the pile, will help to keep the heat constant and uniform. By the time the manure is thoroughly warm, the location of the bed should be made ready. In

selecting a location, it is well to take advantage of a wooded hill, some building, or a high board fence at the northern side to break the wind. It is quite common to build a tight board fence about six feet high, as a special protection from cold and wind. Sometimes the fence has shutters attached which can be let down over the beds or turned up and fastened back when not in use.

CONSTRUCTION.

Hot-beds may be made upon a large pile of warm manure, placed on the surface of the ground, or pits may be dug for receiving the manure. In wet locations, the former method is to be preferred, as standing water will put out the fire in a pile of heating manure just as effectually as it will put out other fires. If the location is a dry one, as where the soil is sandy with a loose, porous subsoil, it will be better to dig a pit for the manure. In either case the manure must extend in all directions several inches beyond the frame that is used, otherwise there will be very little heat at the edges of the bed. Having dug the pit of sufficient depth, the manure being alive with heat, is to be carted and thrown in, a forkful at a time, keeping it as level as possible. It will not do to tread the manure very hard, as the heat would be too much checked, but it should be pressed down slightly by the fork, and a light person may walk once around on the edges. The middle will settle solid enough when the soil is put on in which the plants are to grow. The depth of the manure in the pit will depend upon the season of the year and how long the heat will be wanted. A thick bed will hold heat longer than a shallow one, so the earlier the bed is made in spring the deeper must the manure be laid. Two feet of manure is not too much if the bed is started the last of February or first of March.

Later in April, frames are placed over a foot of manure in beds made for setting out plants that require checking or more space for development. Having filled the pit with manure to the desired depth, put the frame in place over the manure. The frame may be a cheap affair of inch boards for a late bed, but an early one would be better protected by a plank frame and with the earth banked up against it on all sides. The frame should have square corners, and must be the right size to receive the sashes. Sashes are usually about three feet by six feet, with lapped glass laid to shed water. After building the frame, which should be a few inches deeper at the back side, in order to give enough pitch to the sashes to turn off the water from rains or melting snow, the soil to plant in should be evenly spread over the bed to the depth of five or six inches. The soil should be prepared the fall previous, and must be kept in a dry place under cover till needed for use. The soil must have a large proportion of sand intimately mixed through it. This is to prevent puddling and baking under the use of the watering pot.

Good garden loam, old hot-bed manure, and sand, in about equal proportions, will make a rich, mellow soil for receiving the seeds. It will be all the better if it has been freed from weed seeds by sprouting them in the soil a few days previous to planting the garden seeds. If the manure be hot, the weed seeds will mostly sprout by the third day, when a good raking of the bed will utterly destroy them. The bed is now ready for the seeds we wish to sow, and they may be drilled in in rows, or sown broad cast, according to what is to be done with the plants.

PLANTING.

Tomato and other plants which require resetting, to insure a vigorous growth and early maturity, may be sown very thickly, and then taken up and separated when they are set in the cold frame. The cold frame is made just like the hot-bed, except that much less manure is used for supplying heat; if the season is well advanced, none need be used; but if the weather be cold, the transplanted plants will start more readily if a little warm manure be placed under the soil in which they are set. If one has no old hot-bed soil to use in the new bed, any good garden soil may be used, but it should receive a liberal dressing of wood ashes, and some kind of artificial fertilizer. It never pays to be stingy in the treatment of hot-bed plants.

After planting the seeds, the ground should be pressed firmly, by laying down a board and walking upon it. The top soil in a hot-bed dries very rapidly in sunny weather, and if it is not pressed down quite firmly, the seeds are liable to be killed by over drying before they have had time to throw down their feeding roots. Nothing will kill a seed more effectually than to sprout it and then expose to a drying atmosphere. It is sometimes advisable to spread a newspaper on the ground under the glass, to prevent too rapid evaporation, or the glass of the sash may be sprinkled with whitewash, which will obstruct the sun's rays somewhat, and thus prevent too rapid drying of the soil. If the soil is in good condition and the manure beneath is as warm as it should be, the seed will come up before any artificial watering will be needed. Watering before the plants come up is objectionable, as there is usually a crust formed on the soil, which is hard for the young plants to push through, while it also tends to increase the evaporation. A mellow soil firmly pressed keeps sprouting seed in much better condition than a soil packed by sprinkling.

CULTIVATION AND WATERING.

As soon as the plants appear above the surface, the beds will require constant attention. If the soil becomes dry it must be watered, and the water should be warmed moderately and applied late in the afternoon; never at midday. Rain and sunshine together are not in accordance with nature's plans or methods. Unless the soil is already freely mixed with sand, it will be found an excellent plan to sprinkle from a half inch to an inch of sand over the entire bed while the plants are growing. This will make a surface that will not bake by watering, and it will help to conduct the water down through the soil instead of turning it off, as would be the case where much clay or loam is used that would crust over when wet. Plants are much less likely to "damp off," that is, rot at the stem just at the surface of the ground, where plenty of sand is used to "hill up" after they begin to put out their second and third set of leaves.

AIRING.

Having done every part of the work thus far perfectly, all may be lost in an hour's time if the sashes are left off when they should be on, or closed too closely when they should be opened. The plants must have plenty of fresh air, and it must be tempered by opening and closing the sashes just enough and just at the right time. It is useless to attempt a hot-bed unless some one can be on the ground all the time and keep it in mind. During cold nights it must be shut as tightly as possible, a covering of mats or shutters or both being often required. In the morning these should be gradually removed as the sun gets up, and as the day grows warmer the sashes should be opened a little, and, if need be, removed during the middle of the day. Unless the plants are hardened by plenty of fresh, cool air, they will be worthless for setting in the garden. There is always a tendency among hot-bed plants to run up tall and weak. To offset this, it is a good plan not only to give all the fresh air practicable, but to take the plants up and reset them in cooler beds, setting them far enough apart so as to give room for a healthy development.

Just as soon as the weather will permit, the sashes should be left off entirely, so the plants will be perfectly hardy to withstand their final transplanting into the open ground. A well grown hot-bed plant is short and stout above ground, with a heavy mass of fibrous roots below. A plant that has not been taken up and reset before being offered for sale for setting in the open ground is not worth half price. The best plants are those which have been reset two or three times.

After the beds have been emptied of their plants, the frames should be taken up and packed away where they will keep from rotting. The sashes should receive an occasional coat of paint, and broken glass should be replaced by new. In market gardens the same beds are sometimes used for several successive crops, two or more in spring and another in the fall. In such cases the frames may remain so long as the wood keeps sound. A coating of coal tar applied to the wood work will increase its durability.

Every farmer who has some member in his family who will take the responsibility of tending a hot-bed during the six or eight weeks between early spring and settled warm weather, may have an abundance of early plants to set in his garden, and, if so disposed, may reap a considerable harvest from the sale of plants grown at a time when the regular farm work is seldom pressing.—*N. E. Farmer.*

NECROPHORI—BURYING BEETLES.

By J. FLETCHER, OTTAWA.

THE several classes of beneficial insects may be grouped under two heads: First there are those which do actual good themselves; and, secondly, those which prevent others from doing harm It is of the utmost importance that the appearance of all these beneficial insects should be known to those engaged in agricultural pursuits, or many of the most useful of man's auxiliaries, will, without doubt, be frequently destroyed. This is a very easy matter, for the members of the different families, into which insects are classified by entomologists, may nearly always be recognized as such, at a glance, and with very few exceptions the different genera of any family have the same habits.

From the small size of insects, the enormous benefits and injuries which man experiences at their hands, are apt to be underrated or even overlooked altogether. They are, however, becoming more appreciated, day by day, as the labors of specialists are made known to the world. A remarkable illustration of this may be found in the publication of Mr. Darwin's last work, "Vegetable Mould and Earth Worms." Notwithstanding the vast amount of original investigation, of the utmost importance, on other scientific subjects undertaken by this gentleman, the fruits of which have from time to time appeared in his invaluable works, ever since 1837, when he read a paper on "The Formation of Mould," to the Geological Society of London, he has been accumulating facts and making observations, the results of which are set forth in this fascinating work. Some of the experiments are most remarkable, and the care and patience exhibited by this great worker in carrying them out, are very characteristic of the man; and are so graphically narrated that one who reads the book can almost fancy he has seen them performed. The modifications of the earth's surface by the agency of these small creatures is so great as to be almost incredible, were they vouched for by a less accurate experimentalist than Dr. Darwin As the result of various careful observations he found that, on one acre of old pasture ground, no less than fifteen tons of earth are annually swallowed by worms below the surface, and thrown up above it in the shape of castings.

He points out, too, that the burial of ancient Roman and other remains, scattered over the country, in England, is due to worms, which keep continually throwing up the soil from underneath them, and so let them sink.

Among the insects which do actual good, those which perform the office of scavengers are entitled to more than a passing consideration. These useful insects will be found almost entirely among the Coleoptera or beetles, and the Diptera or flies. As Kirby and Spence's valuable work, "Introduction to Entomology," is not easily attainable in this country, I cannot do better than insert what they have written so well on this subject: "All substances must be regarded as nuisances and deformities, when considered with relation to the whole, which are deprived of the principle of animation. In this relation stand a dead carcass, a dead tree, or a mass of excrement, which are clearly incumbrances that it is desirable to have removed, and the office of effecting this removal is chiefly assigned to insects, which have justly been called the great scavengers of nature.

"How disgusting to the eye, how offensive to the smell, would be the whole face of nature were the vast quantities of excrement, daily falling to the earth from the various animals which inhabit it, suffered to remain until gradually dissolved by the rain, or decomposed by the elements! That it does not thus offend us, we are indebted to an inconceivable host of insects, which attack it the moment it falls; some immediately begin to devour it, others depositing in it eggs from which are soon hatched larvæ that concur in the same office with ten-fold voracity; and thus every particle of dung, at least of the most offensive kind, speedily swarms with inhabitants which consume all the liquid and noisome particles, leaving nothing but the undigested remains, that soon dry, and are scattered by the winds, while the grass upon which it rested, no longer smothered by an impenetrable mass, springs up with increased vigor." Many of the Scarabæidæ or Diggers not only live on this filthy material, but dig galleries below the mass into the soil and carry down portions of it, to be food for the young larvæ; the benefit thus conferred is two-fold; not only is the nuisance removed, but a fertilizer is carried down into the soil, and canals are opened by which more may find its way in the same direction, whenever rain falls. The beetles living in dung inhabit it in their perfect as well as larval states; and it is a curious fact, that they are very seldom found to have any of it adhering to them.

"Of the diptera, the larvæ alone derive their nutriment from this source; the imago, which would be suffocated did it attempt to burrow into a material so soft, only lays its eggs in the mass. The members of this order, too, are more select in their choice than the coleoptera—not indeed as to delicacy—but they do not indiscriminately oviposit in all kinds, some preferring horse-dung, others cow-dung, and others that of birds, etc.

"Still more would our olfactory nerves be offended, and our health be liable to fatal injuries, if the wisdom and goodness of Providence had not provided for the removal of another nuisance from our globe—the dead carcasses of animals. When these begin to grow putrid, every one knows what dreadful miasmata exhale from them, and taint the air we breathe. But no sooner does life depart from the body of any creature than myriads of different sorts of insects attack it in various ways. First come the Histers, and pierce the skin; next follow the flesh-flies, some (Sarcophaga), so that no time may be lost, having the remarkable characteristic of depositing their young alive; others covering it with millions of eggs, whence in a day or two proceed innumerable devourers. An idea of the dispatch made by these gourmands may be gained from the combined considerations of their numbers, voracity, and rapid development. One female of *Sarcophaga carinaria* will give birth to 20,000 young; and the larvæ of many flesh flies, as Redi ascertained, will, in twenty-four hours, devour so much food, and grow so quickly, as to increase their weight two hundred-fold. In five days after being hatched they arrive at their full growth and size, which is a remarkable instance of the care of Providence in fitting them for the part they are destined to act; for if longer time were required for their growth, their food would not be a fit aliment for them, or they would be too long in removing the nuisance it is given in charge to them to dissipate."

As soon as the various tribes of flies have opened the way, and devoured the softer parts, a whole host of beetles actively second their labors. Wasps, hornets, and ants claim a share, and before long what was a putrefying mass is only a heap of dry bones, which are soon covered by decaying vegetables and soil thrown up by worms.

Of these scavenger-beetles, none, perhaps, are more interesting than the *Necrophori* or sexton beetles, or, as their name denotes, corpse bearers, in allusion to the singular habits possessed by all the beetles of this genus. They are not content with merely eating their food when they find a supply, but lay eggs in it and then bury it so that no other insects may get it, but that it may be a provision for their future progeny.

These insects may easily be known; they are almost all bright colored, being of a shining black, ornamented with bright orange markings and fulvous-down underneath; the under side of the elytra is often of a bright yellow color, which is very conspicuous when they are flying, these organs then being held erect. They fly and run with great rapidity. When flying they are very difficult to distinguish from humble-bees, and have very much the same oscillating mode of flying backward and forward before any one trying to catch them. The antennæ are very peculiar, consisting of a slender jointed stem, bearing at its end a round knob composed of four flattened joints joined together. There are several species found in Canada, the largest and handsomest of which is *Necrophorus americanus*, Oliv. I have never been able to observe this species working; but some of the other species may be easily watched if a trap is set for them in the shape of some small animal or bird.

The rapidity with which these small creatures will bury a bird many times larger and heavier than themselves, is astonishing. They seem, too, to be gifted with the same instinct as the vulture, for although they are very seldom found hidden like other insects, no sooner is a small dead animal exposed than some of these insects very soon appear, and, after a short survey of the "subject," soon commence operations. If the ground is soft and suitable, they begin at once by making a furrow all round, about the length of their bodies from the animal; the greater part of this work of burying is said to be performed by the male, but I have been unable to verify this. They nearly always work at night, and stop and run under the body whenever a light is brought near them. As soon as the first furrow is completed, another is begun inside this, and the earth is then pushed out into the outside one; the next furrow is beneath the body, and the progress can be marked by the earth that is pushed out all round it from underneath. There is a good deal of running about and inspecting all the time the work is going on, and frequently the workmen will refresh themselves with a meal from the object of their attentions, after which they will take a rest and then will start again, and work away until nothing is visible. They are not even then content, for they will sink small bodies to the depth of a foot from the surface. In this storehouse they deposit their eggs, and then leave them to take care of themselves, and set off in quest of more work to do. If by chance the object they wish to bury is in an unsuitable place, they will accomplish comparatively enormous feats rather than give up the object. Last summer, I noticed one evening a dead swallow lying on a stone pavement close against a building. As I passed I pushed it up against the wall so as to be out of the way; the next morning as I went by the same place I looked if it were still there; but not seeing it was passing on again, when, on the opposite side of the path, and half buried behind a tuft of grass, I found it, and in the feathers and underneath the bird were at least half a dozen *Necrophorus velutinus*, four of which I secured. The distance this had, to all appearances, been dragged in one night, was over six feet four inches. Soon after the eggs and their decomposing receptacle are buried, the young larvæ hatch and begin to devour. They soon grow into long fleshy grubs, narrowed at each end and having the segments distinctly marked, and the upper surface of each one armed with a horny plate, which has strongly toothed edges. These plates serve the larva in the stead of legs, of which it has only three very weak and small pairs. With the assistance of the horny segment-plates, it is enabled to force its way through the soft material in which it lives by alternately lengthening and shortening its body. As these insects during this period never change their locality, legs are useless; but when, after having spun a cocoon, in the earth laid dormant all the winter, and emerged the following spring as perfect insects, they lead an active, roving life, strong and slender legs, suited to their requirements, are provided, showing how nothing useless is created in nature, and how no necessary is found to be wanting.

There are many curious instances on record of the instinct displayed by these insects in providing food for their future young. In Westwood's "Modern Classification of Insects," mention is made of an instance in which some of these insects, in order to get possession of a mole fastened to a stick stuck upright in the ground, undermined the stick so that it soon fell to the earth. From an observation by M. Cadet de Vaux, it appears that while several individuals of some species of Necrophorus labor in concert, those of others work alone.

Latreille states that the larvæ of Necrophorus entirely

consume the buried carcass, leaving neither skin nor bone. Hence it seems that the number of workers is proportioned to the quantity of food necessary for the support of their progeny.

One of the most objectionable features about these handsome and interesting insects is a habit they have of exuding a most fetid fluid, which is derived from the putrid food they feed upon. Unluckily, none of their tribe are free from this objectionable habit, and they never entirely lose the odor.

Among those insects which do good by preventing others from doing harm are found those predacious kinds which live on other insects, and they adopt the most effective means, viz., killing and eating all they find. They belong chiefly to the following families: *Cicindelidæ*, or Tiger-Beetles, are bright metallic tinted, merciless freebooters, armed with sharp, cruel jaws, and furnished with powerful wings and legs. In the larval state, too, they are very rapacious, living in holes in the ground, and only leaving their heads out; they seize and devour every insect which is unlucky enough to come within their reach.

The *Carabidæ* are a large family of most useful insects, destroy innumerable destructive larvæ of *Lepidoptera* and other insects. *Calasomas* are particularly active in killing the different species of cut-worms which work such havoc among all spring crops. There are many most valuable and beautiful insects among the *Carabidæ*, the general appearance of which should be known to all, as both in the larval and perfect states they do an incalculable amount of good by keeping down insect enemies.

A very useful family of beetles, because they keep in check the destructive *Aphides*, is known by the name of *Coccinellidæ*, or lady-birds, and it would be well if the good they do were as well known as they are themselves.—*Report of Entomological Society of Ontario.*

RECENT RESEARCHES INTO THE THEORY OF THE LIVING CONTAGIUM, AND THEIR APPLICATION TO THE PREVENTION OF CERTAIN DISEASES IN ANIMALS.*

By J. L. W. THUDICHUM, M.D., F.R.C.P., London, etc.

THE consideration of virulent diseases to which man and animals are liable constantly engages the attention not only of the medical profession, but of all thinking members of the community. The prevention of these diseases is of course desired by everybody, but it cannot be effected by the medical profession alone, or by the public alone, or by either of them with the aid of the legislature alone, but requires the cordial, constant, and energetic corporation of public, government, and doctors. The public have to co-operate in the prevention of these diseases, not only individually, each by the proper hygienic conduct of his person, family, home, cattle, and land, but also in corporate capacities, as communal representatives; and in the latter case with responsibilities growing with the power which may be attached to the capacity. Such being the case, it is desirable that the co-operation should consist not merely in obedience to skilled prescriptions or man made statutes, but in that intelligent obedience, which is the result of a more or less perfect knowledge of natural things and causes. From this point of view the consideration of virulent diseases becomes a part of natural history which it behooves every cultured person to know just as he knows astronomy, botany, or physics, or history. And this being granted, it will, I hope, require no apology on my part, that the council of this society thought it useful, on public grounds, that the subject indicated by the title of this paper should be discoursed on and discussed in this hall.

Although by the title of the paper I am, happily for myself, confined to *recent* researches, it will be necessary for me to show you that, and how, they are based upon and cohere with knowledge which men of science of many nations have produced, and stored up during long periods of time. This knowledge has mainly been obtained by the study of some of the most virulent diseases of animals, with the aid of pathological experiments upon living animals, and could by no means have been obtained without them; and now the species which furnished the hecatombs of victims of disease, and the insignificant number of subjects for experiments, are about to be benefited, or are already benefiting, by the practical results of these studies, to the extent of their being practically free from the liability to at least the most pernicious of contagions and almost certain death, which formerly troubled their prospects.

Some may perhaps think that there was some inconsistency in my discoursing of the theory of contagion, and yet claiming practical results for its application. To be better understood by these persons who merely follow a common habit of confounding theory with hypothesis, I expressly say that I use the term theory in the genuine Greek sense, as expressing a scientific view which can be made the basis for action. And I further include, for my present purpose at least, in the term theory in general, all theoremata, or theoremes, as special cases, and demand for them, as diagnostic conditions, the properties postulated by Galen, namely, that they must be, before all else, true; further, that they must have a fructiferous influence upon our subject; and lastly, that they must be derived as necessary consequences from the antecedents.

A contagium is a cause of disease which can be communicated from one individual to another, by some material contact or other only; the term contact here includes not only that immediate contact, in which, *e. g.*, a person nursing a patient comes within the object of his attention, but also indirect contact such as that to which a washerwoman is liable when she handles the clothes of a sick person. In all cases a contagium is a material particle, or a number of particles, which is transferred from a specifically sick person or animal to a healthy person or animal, and produces in the healthy person the same disease as that which affected the person or animal from which it proceeded.

In order to understand how such a contagium can be living, it is necessary to be acquainted with the nature and properties of the smallest organisms occurring in nature. From the consideration of all that is known on this subject, it follows that contagia, which can be distinctly recognized as consisting of a number of similar individuals, belong not to the animal, but to the vegetable kingdom, and therefore the term living contagium would require to be supplemented by the adjective vegetable, if it were not probable that all contagia whatever belonged to the world's flora, and not to its fauna. In any case there are no grounds for terming contagia animate, if the condition of animation is allowed to characterize organisms which, in science, are termed animals. In short, contagia, such as we know then, have the characters of the lowest plants.

The term "contagious disease" is, therefore, equivalent to that of "vegetable parasitism." But the equivalence is not absolute.

Itch is contagious. The spider-like (*arachnid*) mite, which is the sole cause of itch (*scabies*), is an animate contagium. It can be transferred from one individual on which it lives, and propagates, and causes eruption, to another healthy one, and cause the same disease of the skin as that found on the body from which it came. It can be killed by chemical agents, and, with its death, all manifestations of disease cease, and all effects heal.

Trichiniasis is contagious. The minute worms can be transferred, in a particular manner, from one individual (human or animal) to another, and, by its multiplication, cause a disease which is very similar to an ordinary contagious disease. But there is a great difference in the manner in which the organism of the animal invaded by any of these animal parasitisms reacts against the invading force. And it is by this reaction mainly, which has a remarkable intensity and effect in the case of contagious diseases, that animal parasitisms are distinguished from vegetable.

The reaction of the organism invaded by a vegetable contagium consists in this, that whenever the organism does not actually succumb, it acquires a new property, namely, that of being thereafter, either for the length of its entire life, or for longer and shorter periods, so to say, inaccessible to the same, or a very similar contagium. Thus, a person is not very liable to contract yellow fever twice; and small-pox, typhoid fever, or cattle-plague so rarely befall the same individual twice, that one attack is generally considered to protect the survivor from a second one. The condition of body thus acquired is generally described as immunity. This immunity is never produced as a result of animate contagium. A man who has recovered from an attack of itch or trichiniasis, is just as liable to a second infection, or any number of infections, by the acarus of scabies or the trichina, as he was before the first attack. But a man who has recovered from the small-pox is not liable at all to contract small-pox again, or for a considerable time at least, and even when the contagium, which would give the small-pox to a healthy person with certainty, is incorporated with his body, it fails to thrive, perishes, and becomes abortive. This undoubted state of immunity from the disease, produced by the disease itself, is one of the most difficult problems of medical science. There is at present no explanation of it for which there could be quoted even the outline of plausibility. It is, however, undoubtedly the result of the reaction of the organism against the contagium and its products. It is a function not of the contagium, but of the organism invaded.

This immunity exists in a proportion of healthy individuals without their having undergone the effects of the contagion in their proper persons. In such cases the immunity may be inherited, or have been acquired by means which do not present themselves as actual contagion. Or it may have been acquired by a vicarious contagion, which, like cow-pox, exhausts the receptivity of the individual for cow-pox, as well as small-pox, or confers the immunity from cow-pox as well as small-pox. For immunity may be the result of an active power acquired, or of the loss of a passive faculty, such as impregnability.

We will now consider some of the best known vegetable parasitisms or contagia, and their action upon the beings upon which they thrive best, and develop their highest power of destructiveness.

In New Zealand there lives a common caterpillar, which, when it is nearly full grown, frequently begins to sicken; a bump appears at its head or neck, and then fungus sprouts out an inch or two in length. When the fungus has ripe spores, the caterpillar dies. You can see caterpillars of this kind, with fungi attached, exhibited in the Natural History Museum in South Kensington. This is the most grotesque vegetable parasitism of which I know. A single spore introduced into the body of a healthy caterpillar will produce the disease; a mycelium forms in the cavity of the body, and the external growth is only the rapid infloration of the hidden growth. In Europe we have a disease of a similar kind, but without the grotesque mushroom sprouting from the surface of the animals, namely, the disease of silkworms, termed muscardine. In this disease the animals die as from unseen poison, and only by close observation after death is a film of fungoid infloration, carrying spores, seen upon their surface. It was the Italian Bassi, who, in 1837, discovered this remarkable fact, upon which all our present knowledge of this subject is based. He cultivated the spores taken from the skins of silkworms which had died from the muscardine or moist moss, and was able to reproduce both mycelia and spores, and with the new generation of spores produced out of the body of the silkworms, he was able to reproduce the muscardine in silkworms, either by inoculation under the skin of the worms, or by infecting with the spores, as dust, the air which the worms had to breathe, or by casting the spores on the leaves which the worms had to eat. He thus handled his disease cause so as to show that it was not only a true contagium, but, at the same time, a good imitation of a miasm

These discoveries of Bassi, which at the time when they were made appeared to interest only silk growers, became the starting point for one of the most perfect deductions ever made in science, but doomed to be ignored and to be forgotten; I allude to the pathological researches of Henle, now professor of anatomy at Göttingen, published in 1840. In one article of these researches the theory of living contagium is developed as a hypothesis in all its details, and it is shown that the features of contagious diseases harmonize with the hypothesis in a very remarkable manner.

But the hypothesis lacked the basis of direct experimental evidence. This evidence could not be got out of the consideration of human contagia (it cannot be obtained so now); these had been investigated with rare patience and skill by thousands of physicians, and yet the essence of the nature of virulent disease was as hidden as ever. The method of experiment had to be discovered by the cultivators of another science, that of botany. It was mainly Schwann, the author of the cell theory, who opened new ground by showing that the phenomena of alcoholic fermentation are connected with the presence and life of elementary minute plants, particularly the yeast-plant.

This development was contested by chemists, who in view of the magnitude of the chemical changes induced during fermentation, endeavored to explain it by analogy more than direct study. And thus it came that what was in itself unexplained, namely fermentation, was made a type to which diseases were compared, and henceforth contagious fevers were termed zymotic diseases, or *zymoses*. This was no doubt partly caused by the observation that "the true or metabolic contagia—the contagia which, in their respective and specific ways, operate transformingly on the live bodily material which they affect," as Mr. Simon has tersely defined them, produce a great chemical motion in the body, which results in the rapid production of highly oxidizable compounds, and their oxidization being effected *pari passu*, the temperature of the body is raised more or less above the normal point, and the state called fever, or *pyrexia*, is produced. Hence, fermentation and fever become comparable, not only by their chemical course, but also by their potential effect. The purely chemical view of fermentation was mainly elaborated and defended by Liebig, and he made it so probable, that it may be said to have reigned supreme almost to the end of his life. It is only during the last ten years that his opponents have made their views generally prevail, and with results of which we must admire, not only the scientific brilliancy, but also the practical utility. Among these, none has worked more arduously and more successfully than Pasteur. During twenty-four years he communicated numerous researches bearing upon alcoholic fermentation. Of these a cardinal one concerned the production by growth, by multiplication, of the yeast cell in artificial nutritive solutions, free from all albuminous substances. From this moment the theory of Liebig had no longer any foundation, and, says Pasteur, the phenomena of fermentation presented themselves as simple phenomena of nutrition, which take place under exceptional circumstances, of which the strongest and most significant one is this, that air may be excluded from the process. This gave a new impulse in the direction to the study of animal contagia. They reverted to the method of Bassi and his follower Audouin, and to the line of thought so well worked out by Henle. In 1863, Davaine resumed his studies of the bacterium of splenic fever of cattle, which Rayer had first shown to be the essential contagium of that disease, by experiments upon living animals, but without any new results. Chauveau, however, by experiments upon contagious matters, such as those of small-pox or cow-pox, endeavored to uphold the proposition that all contagia are particulate, that all contagiosity in a mixture (such as animal contagia are) resides in its solid particles and not in its liquid part. After the experiences of the German-French war of 1870, we find the wound-poison ascribed to microscopic organisms by Klebs, and we find the same conviction in this country raised to a general theory, and applied with apparently excellent results to the treatment of all wounds by Lister.

In 1876, an important progress in the direct appreciation of contagia was made by Koch, then working in the botanical laboratory at Breslau. He sowed the bacteria of splenic fever in inorganic solutions similar to those in which Pasteur had reared yeast-plants, and found them grow, develop their germs or spores, and then again grow into bacteria. The new generation of bacteria proved as disastrous to animals as those taken from animals directly. Here, then, was the true or metabolic contagium found out to be an alga-like low plant, to grow in proper media like Bassi's muscardine spores, and to kill as certainly after as before the digression into and propagation in cultivation media.

There is a disease of fowls, called in France "cholera of chickens," from which many die, when once it has got access to a fowl-yard. The animals affected become torpid, are entranced with somnolence, and die without moving from the spot, the head, as in sleep, under the wing. This disease, too, is caused by a microscopic organism, first suspected by Moritz, a veterinarian of Upper Alsatia, figured by Peroncito, a veterinarian of Turin, and cultivated by Toussaint, a veterinarian of Toulouse, in the manner in which Koch had cultivated the bacterium of splenic fever and with the same success. This organism was now studied by Pasteur, and he found that, while it throve well in chicken broth neutralized by soda, it refused to live in decoctions of yeast, such as would support the splenic fever bacteria, and enable them to multiply. The chicken cholera microbion killed chickens rapidly after inoculation; it did not kill guinea pigs, but merely made them ill for a time, by producing a small abscess. The contents of the abscess always contained the microbion, which when re-inoculated to chickens, killed them rapidly. Chickens which merely ate some of the pus from the abscess of the guinea-pig, died rapidly, and the fæces which they voided during the short sickness swarmed with the microbia. The microbia were easily destroyed by a little diluted sulphuric acid, but they retained all their virulence after cultivation in neutralized chicken broth; and this virulence was so great that, if the point of a needle was dipped into a cultivation solution in which the microbion was growing, and was then plunged into the tissue of a fowl, the latter died—mostly in twenty four hours. Of twenty fowls thus treated, all twenty died in two or three days—most commonly in fifty four hours. Pasteur now found that by certain changes in the mode of cultivation of these microbia (changes which will be alluded to lower down), the infecting energy, or as we perhaps better express it, the metabolic virulence, could be greatly diminished. The modified microbion would make twenty chickens specifically ill, but kill few or none. And these twenty or eighteen chickens, after recovery from the modified disease, would be protected from the influence of a renewed introduction of the same contagium, as well as of the first always fatal form of the disease. Pasteur had therefore repeated upon fowls the old experience of protection by inoculation with a modified specific contagium. Inoculation with small pox was based upon the recognition of the existence of such modified, or mild small-pox. Cow-pox, which was supposed to be a contagious disease peculiar to the cow, and to act vicariously in protecting men from small-pox, were supposed by some to be modified small-pox only. And this view was sufficiently strong with some—as with Badcock of Brighton, Ceely of Aylesbury, and Green of Birmingham—to induce them to inoculate cows with small pox, and to use the (modified) contagion thus produced for the protective inoculation of men, commonly termed vaccination. Much of the so-called "vaccine" lymph now used in England is actually small-pox lymph modified by one passage through the heifer, and many passages through human beings. But in the case of small-pox and vaccine, it has not yet been shown that the virus is a living being; whereas in the case of the virus of the fowl-cholera, the "mitification," if I may be allowed the term, was effected after the living nature of the contagium had been ascertained.

When the microbion in its virulent state is inoculated in the great pectoral muscle (the breast of the fowl), it multiplies there, and destroys much muscular tissue. But at last it becomes confined in a cavity with pus, and with the piece of muscle destroyed, continues in it as a sequestrum. Here the general disease ends; but the microbion remains living and capable of propagation in new individuals. The abscess may be emptied out and will heal with the necessary contraction by loss of substance. Now the pectoral muscle is protected from the effects of any similar inoculation; it has acquired a special immunity, in which, if I understand

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M. Pasteur right, the rest of the body of the fowl does not share. The immunity of the entire fowl is only obtained by protective inoculation with the modified, not with the original, so to say, wild poison. Pasteur supposes that this immunity of the muscle was, in fact, incapacity to nourish the microbion, caused by the suppression (or removal in the shape of pabulum) of some principle or matter which life does not restore, and without which the microbion cannot be developed. This local immunity is part of the question of the immunity of entire organisms. From this immunity, says Mr Simon, the inference seems unavoidable, that each contagium operates with a chemical distinctiveness of elective affinity on some special ingredient or ingredients of the body; and that exhausting this particular material in febrile process, which necessarily ends when exhaustion is complete, is the bodily change which the contagium specifically performs.

However that may be, it is certain that, at this point, the investigation of the effects of living contagia must be taken up by the pathological chemist. For the phenomena indicate various chemical changes, not only of parts of the body, but also of matter emanating probably from the microbia themselves. For when, *e. g.*, the microbia of the fowl cholera are cultivated in a proper previously sterilized solution, and when this solution is now filtered so as not to contain any microbia; and when this solution, free from microbia, and which cannot therefore produce any disease like fowl cholera by inoculation, is injected into the subcutaneous tissue of a fowl, the animal shows some nervous disorder, and some yawning-like motion of the beak; it then becomes somnolent as in the fowl cholera itself, but after about four hours recovers as from a dose of a narcotic poison. The microbion, therefore, produces a narcotic poison during its life, which acts upon the nervous centers. The disease, as a whole, consists therefore of lesions of different orders; one caused by the microbion, its obstruction of lymph—and blood-vessels, its abstraction of oxygen from the blood-corpuscles and other effects; the other order being chemical effects of a truly poisonous kind, caused by substances new to the economy, and excreted by the microbion, or left as residues of decomposition which it engenders.

But I must not discuss at too great length a disease which has probably little practical importance in this country. The fowl-yard has its diseases, and diphtheria is one of them Young pigeons die frequently of the same disease. It would be well if all could be protected or cured. We, for our part, must pass to perhaps the greatest result of Pasteur's studies, namely, the protection of cattle—oxen, cows, and sheep—by protective inoculation, with a modified bacterium of splenic fever or anthrax, against the true and hitherto frequently fatal disease, splenic fever. Chauveau, of Lyons, while experimenting with splenic fever contagium on sheep, which he had bought in the open market at Lyons, had found that nine sheep in succession were proof against it. On inquiry, he learned that these sheep had been imported from Algiers. He then imported seven sheep from Algiers directly (Constantine), and inoculated them with splenic fever contagium of a virulent kind. A test-sheep, from Dauphinée, was also inoculated. The latter died within three days, while the seven Africans showed no splenic fever symptom, except a slightly raised temperature. Five of the Algerian sheep were inoculated twice more, with test animals by the side of them; among the latter being Tuscan sheep and lambs, Piedmontese sheep, and a rabbit. All the latter died, while the Africans exhibited a perfect immunity. Chauveau now went to Algiers, and experimented further; out of forty seven sheep inoculated, only eight took the disease and died; thirty nine resisted to all repeated inoculation. Thus it was proved, for the first time, that some sheep could resist the splenic fever poison, which, with European sheep, had been always fatal.

Pasteur now investigated, with the aid of the French Government, the manner in which animals might become infected with splenic fever. When sheep were made to eat clover (*lucerne*), on which bacteria, reared from splenic fever contagium, had been poured, several died, but after a period of incubation extending sometimes to eight and ten days, while the greater number escaped infection. It was, therefore, probable that many of the infections occurring in France, and which amount to three per cent. of all the flocks annually, were caused by bacteria accidentally on the ground and on food, and swallowed by the animals with their food while pasturing. This surmise was proved, experimentally, to be probable. When animals dead from splenic fever were buried in arable or pasture-land, and healthy animals were allowed to pasture over the graves, the latter became infected with splenic fever. It was now shown that, when the splenic fever contagium is in the filiform stage, it perishes with the putrefying body, as it cannot live without air; but when it is in the stage of spores, or germ-corpuscles, it is not affected by want of air, and survives. Such spores are found in and above the burying-places of animals dead from splenic fever ten and fourteen months after burial, and are capable of causing the disease in new animals. Even above animals buried two meters deep, these spores were present two years later. These germs are carried to the surface by earth worms, in whose interior they are also found. The little cylinders of earth, deposited by the worms as fæces, contain the germs of the splenic fever contagium; and the rain, when disintegrating these little heaps of cylinders, spread the germs about, causes them to adhere to adjacent vegetables, and to be carried into watercourses or ditches.

Pasteur now proposed prophylactic burial of all animals which might die from splenic fever, and believes that with these measures alone the disease could be stamped out in a few years. (It had been stamped out on German farms in Saxony, an experience which is related in a letter from the Saxon Minister to the French Court in 1865.) Meanwhile, Toussaint made experiments concerning the inoculation of cattle with a mild splenic fever contagium, for the purpose of protecting them in the same manner as men are protected from virulent small-pox, by inoculating with a mild form. These experiments succeeded partially; some animals died, but the survivors, which were a great majority, were protected from the effects of renewed inoculation. Similar experiments were successfully made in this country by Greenfield, now of Edinburgh. On the whole, it was again found by test experiments that cows are much stronger in resisting splenic fever than sheep. Of twenty cows which were inoculated with splenic fever in 1850 to 1852, by the *Association Medicale de Chartres*, only one died, while of forty-seven sheep inoculated by the same association, thirty-five died and twelve survived. While, therefore, the cow does naturally frequently fall ill with splenic fever, it does not always die, or rather rarely dies, while sheep die in the great majority of instances in which they become infected, Barbary sheep always excepted.

Pasteur now studied further the mode of attenuating, as he termed it, the contagion of fowl cholera. He had observed the first attenuated virus when he took some from a fowl which had indeed died from the cholera, not, however, from the acute, but from the chronic form, and had cultivated it for weeks and months in successively renewed solution. At first it lost nothing of its virulence; but when the cultivation was renewed unintermittedly during from six to eight months, and at longer intervals between the sowings, the fatality of the disease, following inoculation with this cultivated contagium, diminished or disappeared. A contagium was produced, which caused a mild, non-fatal disease, and the animal which had undergone this process was protected from the effect of the most virulent contagium, as has already been stated above. What is of importance now is the cause of the attenuation. Pasteur surmised the oxygen of the air to be the principal cause of it. If the virus is cultivated in hermetically sealed tubes, with only a limited amount of air, no attenuation takes place, and a tube, thus charged, and kept for as many as ten months, retains the contagium in all its original virulence. This feature he believed to be a principle to which other contagia might show obedience. This was found to be the fact for the splenic fever contagium. Cultivated in the presence of air, and resown at long intervals (the intervals are not accurately stated, and differ for different cultivations, as some of the crops die after short cultivation, particularly when they are already somewhat attenuated, while others, of virulent strength, may have their sowing deferred much longer), the bacterium changed its character; it became incapable of causing death in the most susceptible animals, but retained the power of producing some slight febrile disorder, after the disappearance of which the animal was inaccessible to the most virulent form of the contagium. It was as proof against splenic fever as a vaccinated person is against small-pox. The experience was now raised to a method of protecting herds from splenic fever. Test experiments were made, at the public expense, and under responsible inspection and control. Pasteur having predicted the results to the commission, which had made a record of the prediction, was fully borne out by the results which the commissioners had to verify. All non-protected animals which had been inoculated with active virus were dead; all animals previously protected by inoculation with modified virus, and now tested with active virus, were living and well. Since that time, many thousands of French animals have been inoculated with the modified virus, with the view of protecting them from spontaneous splenic fever, *i. e.*, splenic fever which they might accidentally contract where the germs of it occur.

Many are the diseases which are ascribed to, or are actually proved to be caused by bacteria, similar to, though mostly much smaller, than those of splenic fever. One of the best known is pig-typhoid, so ably elucidated by Dr. Klein. Lately, a new one has been discovered by Dr. Ballard, probably also originating in the pig, and affecting men who consume the pork—even when cooked.

But I must hurry to conclude this very imperfect account of one of the most important subjects of modern science. There are not wanting objectors to the protective inoculation of animals, as there are those opposed to vaccination. They will do good by opposition if it be founded upon truth and experiment, particularly on animals. Probably the stamping out of this and kindred diseases by isolation of cases and germs might be preferable to general inoculation. But antidotes—true medicines—are wanted for most of the virulent diseases, and it is in their discovery that the chemical method of investigating disease will, in the future, meet with its greatest successes.

DYSPEPSIA AMONG FARMERS.

IN the last annual report of the South Carolina Board of Health is an article by Dr. S. Baruch, now of this city, upon the "liver complaint" among the farmers and laborers of the South. It contains facts and suggestions which have a wide interest and importance.

In a long experience among the rural and laboring population of South Carolina, the author had noticed the great frequency of the so-called "liver complaint." The patients presented more or less of the following symptoms: "Face pale, skin shriveled, tawny or tallowy, lips pallid, white of eyes bluish and glistening, tongue covered with a thin white fur, pain and fullness at pit of stomach after eating, nausea, eructation of gas or hot water (water-brash), oppression of chest after meals, palpitation of heart, rapid breathing when walking fast, constipated bowels, languor, loss of appetite, wandering pains in various parts of the body, etc."

Now, these symptoms indicated, according to Dr. Baruch, not liver trouble, which is comparatively rare in the South, but dyspepsia. And the extreme frequency of this dyspepsia led our author to investigate its cause. This he found to lie in three things: improper food, improper cooking, and too rapid eating.

The food of the Southern laborer is chiefly "hog and hominy," *i. e.*, pork and corn-meal in various forms. As a rule, the pork used is salted. This process, according to Liebig, as quoted by Dr. Baruch, diminishes the nutritive value of the meat one-half. It also makes it less digestible. In addition to this, the constant use of the same kind of cooked food seems to have an injurious tendency. The Southern farmer, however, not only eats this pork constantly, but eats a great deal of it at a time. The remark is quoted that American laborers eat as much animal food in a day as would supply three laboring-men in Europe. Physiology indeed confirms what observation suggests, that man is essentially and distinctively a gluttonous animal; and the American laborer seems to be a peculiarly good illustration of this anthropological characteristic.

Dr. Baruch describes the Southern mode of cooking food. His endeavors to be amiable in his criticisms do not disguise the fact that the country housewives make bad bread, doubtful pastry, and fry, with little skill, almost everything that can be cooked by that dyspepsia-compelling process. The frying-pan, however, is not a distinctively Southern institution, but is coextensive with the American eagle and the star-spangled banner. It is the *bête noir* of the hygienist, and has received deserved anathemas from every quarter. But it still maintains the supremacy which it gained in the kitchens of our fathers, and we fear is likely to continue to do so.

The evil results of rapid eating have been often told, with probably some good effect, especially upon the rising generation. It is children who must be taught to eat slowly, and the dyspeptic parents of the present day are making wise teachers.

The prevalence of dyspepsia among the rural population is not confined to the South. A somewhat similar account to that of Dr. Baruch was, says the *Medical Record*, given some years ago by Dr. John Ordronaux, whose criticisms referred to New York and New England.

PHYSIOLOGICAL EFFECTS OF PROLONGED BATHING.

IN an investigation on the above subject, published in *Paris Médical*, for December, and giving a very accurate account of the effects which baths produce on the system, according to their duration and temperature, Dr. Théry has arrived at a number of conclusions which are both interesting and true. He says: A bath at 97° Fahrenheit is without effect on the circulation. All baths below 97° reduce the action of the heart. The beats, however, acquire greater energy. The pulse retains perfect regularity. Circulation is not reduced in direct ratio with the temperature of the water, but it is influenced by the duration of the bath.

When baths at 75° or less are prolonged for an hour, arterial pulsation continues decreasing after exit from the water. Baths at or below the temperature of the body quicken circulation. This acceleration is proportional to the temperature of the water. The pulse is irregular and the heart fluttering.

Baths between 97° and 99° are without effect on animal heat. Baths below 97° reduce the temperature of the body. Baths between 92° and 97° cause a loss of 0·97° to 1·46°; this reduction is obtained within half an hour; after this the thermometer remains stationary, even should the bath be continued for two hours.

In baths at 86° or under the fall in temperature is more gradual; it is in proportion to the duration of the bath.

The first effect of a bath at 72° or less causes a slight elevation of temperature. The fall in temperature obtained by means of a half hour bath at 93° is almost equal to that produced by a bath at 72° continued for an hour. After a bath above 82°, continued for an hour or two, temperature has an upward tendency, although for the following twelve hours it remains from 0·5° to 1° below what it was before the bath. After a bath under 81°, the thermometer continues falling during the next twenty minutes following exit. During the twelve hours following a prolonged bath, at from 64° to 81°, the thermometer indicates a reduction of 1° to 1·50° from the initial temperature.

All baths at or above the temperature of the body produce a rise in central temperature. The rise, in proportion to the temperature of the water, is progressive. A bath at 108°, continued for nineteen minutes, raises the temperature of the body to 104°. A bath at 68° progressively raised to 95° produces a fall in temperature. A bath at 97° gradually reduced to 75° causes, as a first effect, a fall in temperature; but subsequently, in proportion as the temperature of the bath decreases, that of the body rises. It is only between 91° and 97° that baths can be continued for a long time without causing suffering.

In water, the sensation of cold acts by reflex action, first on the smooth muscular fibers, and later on the striated.

Hot baths predispose to syncope; they are followed by profuse perspiration.

All baths, when long continued, are debilitating.

PURE CHLOROFORM.

THE following easy tests are recommended by Professor Regnauld, in *Le Progrès Médical*.

1st. Chloroform should have an agreeable odor.

2d. It should not redden blue litmus paper.

3d. Added to a solution of nitrate of silver, it should neither give a precipitate, nor even cause cloudiness.

4th. It should not become colored, when brought to the boiling point along with a concentrated solution of caustic potash.

5th. Sulphuric acid should not blacken even when brought in contact with chloroform.

The above tests are not difficult; besides these, there are others, such as determining the *specific gravity* and the *boiling point*, which, however, are more within the province of a chemist; but no chloroform should ever be used for anæsthetic purposes which does not comply with the above requirements.

Chloroform, even when perfectly pure, is liable to sudden changes. Exposure to light, an imperfect cork stopper, or a but partially filled bottle, are conditions which may affect its purity; hence it should be occasionally tested, especially before using. Dr. Yvon is of opinion that the sulphuric acid test is not fully reliable; on the other hand, as caustic alkalies are used for the purpose of rectifying chloroform, there may be circumstances when the absence of coloration with an alkaline solution is not positive evidence of purity; he, therefore, recommends, as a far more delicate test, the combined action of permanganate of potash and a caustic alkali.

As a reagent, he uses a solution of:

℞.	Permanganate of potash	gr. xv.
	Caustic potash	℥ ijss.
	Distilled water	℥ vijss.

This solution is of a handsome violet red color, and when in contact with *pure chloroform*, remains unchanged. But if the chloroform has been *imperfectly* rectified, the solution is acted upon, and its color gradually changes to green.

To be successful, this test requires considerable nicety.

A REMARKABLE WOUND OF THE BRAIN.

THE *Lancet* for January, 1882, reports the following wonderful case, which was presented to the Société de Médicine de Paris by M. Dubrisay. A man determined on suicide held in his left hand a dagger about three and one-third inches long and one-third of an inch wide, and placing the point against his skull, struck it several blows with a mallet, believing that he would fall dead at the first blow. To his surprise he felt no pain, and observed no phenomena. He struck the dagger, in all, about a dozen times. When seen, the handle of the dagger was projecting from the skull at the junction of the posterior and middle third, a little to the right of the middle line, and in a transverse position. All of the blade except one-third of an inch was embedded. The most strenuous efforts were made to remove the dagger, without avail, so tightly was it held in position. Neither did these efforts cause any pain. The man then *walked* to a coppersmith's, where he was fastened to rings fixed in the ground, and by strong pincers the handle of the dagger was fastened to a chain, which was placed over a cylinder turned by steam power. At the second turn the dagger came out. The patient, during all this time, suffered no pain or inconvenience, and in a few minutes *walked* to a hospital, where he remained in bed for ten days, but without fever or pain. He then returned to his work, and the wound gradually healed. By driving the dagger into the head of a cadaver

in the same situation and to the same depth, M. Dubrisay found that, without injuring the superior longitudinal sinus, it had passed into the cerebral substance, just behind the ascending parietal convolutions, and thus behind the motor zone; the point had not reached the base.

CROTON OIL.

THE following account of the researches of M. L. Julliard on croton oil is from an article in the *Union Pharmaceutique:*

The question which the author set himself to decide was whether pure croton oil was or was not soluble in alcohol, the accounts given by different authors concerning its solubility in that menstruum being discordant. It is, however, very generally known that by repeatedly treating croton oil with alcohol its purgative, acrid, rubefacient and general active properties are greatly weakened, if not wholly destroyed, the remaining oil being comparatively mild. According to M. Desnoix, alcohol at 95° per cent will dissolve two-thirds of the oil, but M. Julliard's experiments reversed these figures. The "Dictionary of Adulterations" of Chevallier and Baudrimon state that croton oil is entirely soluble in alcohol at 40° B.; while the Dublin Pharmacopœia denies it altogether. Croton oil is rarely prepared in our pharmacies, no doubt on account of the inconvenience connected with the manipulation of the seeds of *Croton tiglium*, owing to the acidity of the dust arising from them, which it is almost impossible to get rid of. The greater portion of the croton oil used in France is imported from India through England, and it is pretty certain that by the time it reaches the French consumer it has been already adulterated with castor or some other native oil, the presence of which it is difficult to determine with any degree of certainty. Hence the differences in solubility in alcohol that are to be found in the text-books on the subject. M. Julliard has met with commercial specimens that were not even mild rubefacients. Some authors attribute the active properties of croton oil to the presence of resin; others, among whom may be mentioned Pelletier, Caventou, and Guibourt, ascribe them to crotonic acid, while Dublanc absolutely denies the existence of this acid, and Schlippe puts them down to a peculiar principle which he calls crotonal, so that none of the authorities are really agreed as to what is the really active principle of this oil. It is, however, admitted that this principle, whatever it may be, is extremely volatile, so that in order to investigate the properties of croton oil thoroughly one ought to have specimens which have been prepared as recently as possible. It is therefore better to prepare the oil for one's self rather than trust to the commercial article.

M. Julliard's specimens were prepared in the following manner:

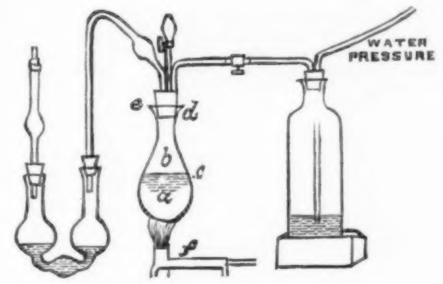
The *Croton tiglium* seeds (it matters little, according to M. Julliard, whether they are fresh or not) are thrown into a porcelain dish, covered with water, and well stirred with a stick, the water is poured off and the operation is repeated. The seeds are thoroughly dried in a cloth and ground to a coarse powder in a drug mill, care being taken to separate those which are hollow, the latter description of seeds being generally in the majority. A certain weight of this powder, say 50 grammes, is treated with double its weight of pure ether or carbon disulphide in a funnel plugged with a pledget of cotton wool, passing the filtrate a second time through the powdered mass. The resulting liquid is then evaporated either spontaneously, or at a very gentle heat over a water bath. By this means from 15 to 16 grammes of a very active oil are obtained from the above quantity of seeds. The oil should be kept in small stoppered bottles covered with bladder to prevent loss. If carbon disulphide is used for the extraction of the oil it always retains a slightly sulphurous odor.

ESTIMATION OF ORGANIC NITROGEN IN LIQUIDS AND SOLIDS.

By WILLIAM BETTEL.

PRELIMINARY NOTICE.

THE difficulty and expense of Dr. Frankland's process for organic nitrogen determination led me to devise a method less expensive than the soda lime process, and unfailing in accuracy, easily worked and estimating either large or small quantities of nitrogen as ammonia by titration or Nesslerizing. I found that by removing nitrates by the copper zinc couple, I could easily estimate the total organic nitrogen in solution by evaporation of water (after removing ammonia, free, and from decomposition of nitrates), with pure solution of caustic soda in a copper flask of peculiar shape, finally evaporating to dryness and igniting, adding water, and redistilling. I could, by suitably collecting the ammonia, obtain results which agreed with the previous history of the water as regards contamination. Having perfected the method I found that urine, abnormal and healthy, and organic fluids in general, including milk, beer worts, extracts, etc., containing no nitrates, could be thus examined far quicker than by any



FLETCHER'S ARGAND.

other known process for total nitrogen estimation, while for simplicity and accuracy it resembled an ordinary ammonia estimation by distillation. Where, upon ignition, cyanides are formed in the flask, sufficient permanganate is added to oxidize to cyanates. These by ebullition are converted into ammonia, and so estimated. I have obtained theoretically accurate percentages of ammonia from ferrocyanide of potassium, urea, uric acid, hippuric acid, albumen, etc., and slightly higher results for other substances, solid and liquid, than yielded by the soda lime process.

At present I will content myself with giving a sketch of the copper flask I use for general work, merely mentioning that the apparatus is in use in two large breweries in the country for daily examination of yeast, malts, worts, and beer. The capacity of the flask is about 300 c.c., and is made in three pieces, *a*, beaten out of stout sheet copper, and brazed to *b*, made of drawn tube, at junction, *c*. The copper cup, *d*, is intended to hold a little water to cool cork inserted in neck, *e*, when the lower part is heated to redness. The cork is triply perforated to admit of stoppered separating funnel tube, tube from hydrogen gas-holder (conveniently made out of two "Winchester quarts"), and the third to either condenser or bulb arrangement with normal sulphuric acid, with methyl-orange as indicator.

The accompanying drawing shows the apparatus as arranged for titration of NH_3.

I have had a number of the copper flasks made especially, and shall be happy to supply them with the necessary fittings to any chemist, with the mode of procedure.—*Chemical News.*

THE EARLY HISTORY OF GAS-LIGHTING.

IT has been known for many generations that sometimes coal-seams yield a combustible gas. In the neighborhood of Wigan, England, during the latter part of the seventeenth century, a Dr. Clayton observed gas issuing from the ground, and from the Philosophical Transactions for the year 1677 we learn than Mr. Shirley made some experiments on the production of gas from coal, obtaining what he describes as "black oil" and a "spirit," evidently meaning coal-tar and gas. Much more satisfactory reports of similar experiments are given in the chemical essays of Dr. Watson, published during 1767, by whom, in the report of an experiment on this subject, we are told that from ninety-six ounces of Newcastle coal he obtained twelve ounces of water and gas tar, twenty-eight ounces of "air" or gas, and of coke fifty-six ounces. A few years later, Earl Dundonald tried experiments in gas-lighting at Culross Abbey. It appears, however, that these experiments on the distillation of coal were made for the production of tar. The Scotchman, William Murdock, is considered the real inventor of gas illuminating. In 1792, he lit his workshop at Redruth, Cornwall; and in 1802, the first attempt on anything like an extensive scale of illumination was established at the manufactory of the renowned Boulton & Watt, Soho, near Birmingham. While this was taking place in England, and probably without any knowledge of it, a Frenchman named Lebon, succeeded in lighting a house in Paris with gas. Other works followed the example of Soho, a Manchester cotton-mill being the next, in 1804. In the year 1807, a German named Winson used gas to light Pall Mall, and five years after he originated the first gas company, "The London and Westminster Chartered Gas-Light and Coke Company," while the French did not adopt this method of public lighting until 1820.

HYDRA.

ONE of the chief architectural features of Tunis and Algeria are the remains of the old Roman buildings and temples, the relics of the occupation of North Africa under the Emperors. Many are in excellent preservation, while others have been converted into dwelling-houses or factories, and their architectural beauties considerably injured. Our engravings depict the ruins of Hydra, the Roman settlement of Ammædara, not far from the Algerian frontier. Through this town, last October, General Forgemol passed on his march from Tebessa to Kairwân to join General Etienne, who was advancing from Susa, and General Logerot, coming from Tunis. At Hydra there was some sharp fighting between the French, under General Bonie, and a detachment of the Fraichiche tribe, the Arabs being eventually repulsed, after twice attacking with much dash and bravery. To return to our pictures. The Hydra ruins are stated to be exceptionally fine, consisting of tombs, colonnades, triumphal arches, etc., all in a good state of preservation. There also is one of the most important triumphal arches in North Africa. A peculiar feature is the unusual height of its entablature, which is half the height of the columns.—*London Graphic.*

ANCIENT ROMAN ARCHITECTURE AT HYDRA.

ON THE PHYSICAL CAUSE OF THE OCEAN BASINS.

Geologists have reason to thank Prof. Ball for directing their attention to the remarkable investigations of Mr. G. H. Darwin, upon "The Precession of a Viscous Spheroid, and the Remote History of the Earth" (Phil. Trans. Roy. Soc., part ii., 1879). Prof. Hull has already been led to point out one result which appeared to him to flow from them, in showing how the ancient tides may have produced the planes of marine denudation, though Mr. Darwin has since expressed doubts as to the legitimacy of this conclusion. I wish to offer another speculation arising from Mr. Darwin's work, which I think may account for the hitherto unexplained distribution of land and water upon the surface of the globe.

Herschel remarked long ago, in his "Physical Geography," that the prevalence of land and water over two opposite hemispheres "proves that the force by which the continents are sustained is one of *tumefaction*, inasmuch as it indicates a situation of the center of gravity of the total mass of the earth somewhat eccentric relatively to that of the general figure of the external surface—the eccentricity lying in the direction of our antipodes: and is therefore a proof of the comparative *lightness* of the materials of the terrestrial hemisphere." In my "Physics of the Earth's Crust," just published, I have shown reasons for thinking that the distribution of the materials of the earth, which gives rise to this condition, is of the following kind. I accept on the whole the theory that the earth is a hot globe, of which the superficial crust is rendered solid by having become cool, and that the central part is solid, either from great pressure, or from whatever other cause may be assigned, an intervening layer beneath the cooled crust still remaining liquid. The layers of which the whole is composed are arranged in order of their density. Now I have given reasons for believing that Herschel's "comparative lightness of the materials of the terrestrial hemisphere" arises from the fact that the cooled crust beneath the continents is intrinsically less dense than that beneath the great oceans. I think that the crust beneath the continents consists of the cooled acid, or granitic, and therefore lighter magma, which ought naturally to have formed originally the entire superficial portion of the globe. But I conclude that the bottoms of the great oceans consist nevertheless of a crust formed out of the cooled basic layer. Beneath the cooled crust the laws of hydrostatic equilibrium would require that, if the substratum is truly liquid, it should be of the same density under both these areas. I also conclude that the upper surface of the basic crust which forms the floor of the oceans is really depressed below the mean surface of figure.

To these conclusions I arrived without being able to suggest any satisfactory explanation of the facts. I saw that they agreed with and were supported by the view of those geologists who assert that the great oceanic and continental areas have never changed places; but neither could I any better see the reason for this.

Let us now inquire whether Mr. Darwin's researches throw any light upon the subject. I shall refer chiefly to the summary and discussion of results appended to his paper, for it is small blame to a sexagenarian, not a professed mathematician, to admit that to follow the *calculations* is beyond the scope of his powers. As I understand Mr. Darwin, he thinks it probable that the moon and the earth were once a single mass, and that at the time when this mass was rotating at the rate of about one revolution in five hours the whole separated into two portions, the smaller of which went to form the moon; and that the moon then began to recede from the earth, until now, after the lapse of fifty-four millions of years *or more*, it is at its present distance. The ellipticity of the mass when rotating at the above-named speed would be about one-twelfth. [This would make the mass very much less compressed than an ordinary orange.] He does not think it probable that this amount of ellipticity would cause the spheroid to break up simply from the centrifugal effect of the rotation; but he suggests judging from the calculated period of a gravitational oscillation of a fluid spheroid, of uniform density equal to the mean of the earth, viz., one hour thirty-four minutes, that the period of the free oscillation of a spheroid "consisting of a denser nucleus and a rarer surface," but of the same mean density as the earth, might coincide with the period of the bodily solar tide at that time. "It seems to be quite possible that two complete gravitational oscillations of the earth in its primitive state might occupy four or five hours." "Accordingly the solar tides would be of enormous height." He then adds: "Does it not then seem possible that, if the rotation were fast enough to bring the spheroid into anything near the unstable condition, then the large solar tides might rupture the body into two or more parts? In this case one would conjecture that it would not be a ring that would detach itself."

I now proceed to build my speculation upon his. It is obvious that, according to the above theory, the act of fissiparturition by which the moon was born must have been sudden. One of the two solar tidal protuberances broke away from the earth to inchoate a separate existence. A great but shallow hole must consequently have been formed, whose center would have been on or near the equator. Prof. Ball says: "Not for long would that fragment retain an irregular form; the mutual attraction of the particles would draw the mass together. By the same gentle ministrations the wound on the earth would soon be healed. In the lapse of time the earth would become as whole as ever, and at last it would not retain even a scar to testify to the mighty catastrophe."

I form a less hopeful prognostication. I think the ocean basins are the scar which still testify to the place of separation.

The density of the moon is 0·56654 time that of the earth. Putting the mean density of the earth at 5·5, this makes the density of the moon 3·1. The density of granite is about 2·68, and that of basalt 2·96. Consequently the density of the moon is a little greater than that of the basic layer of the earth's surface, which I think we may expect to occur at the sea-board at a depth of about 25 miles. The entire mass of the moon is 0·011364 of the mass of the earth.

Accordingly, it would require a layer of about 31 miles thick, of the density of granite, to be taken off the surface of the primitive mass to make a body of the mass of the moon; and if the mean density of the matter removed was the same as that of the moon, a somewhat thinner layer would suffice. But if we reduce the area of the skin removed to the area of the oceans, it would require to be $\frac{197}{146} \times 31$, or about 41 miles deep. Hence a uniform layer rather less than 41 miles thick taken off the oceanic areas would be sufficient to make the moon.

Of course the layer removed would not, in fact, have been of uniform thickness. But the above estimate gives an idea of the size of the cavity which would be produced. What then would happen? This would depend upon whether the surface had already become at all solid. I conceive this would be the case at a very early stage, judging from the manner in which a solid layer forms on the liquid lava of Kilauea. The hole would therefore fill up by the rise of the liquid from below, rather than by the lateral approach of the edges of the wound. When the raw surface again solidified we should have a crust of greater density over the area in question, because formed from a lower and denser layer, which would have risen not quite to the level of the lighter crust. There would, however, have necessarily been a certain amount of flow in the upper fluid layers toward the cavity, and this would have carried the cooled granite crust which, floating on it, still remained upon the earth along with it. What was left of the granitic crust would therefore be broken up into fragmentary areas, now represented by the continents. This would make the Atlantic a great rent, and explain the rude parallelism which exists between the contours of America and the Old World.

The sudden rupture of so considerable a fragment from the rotating spheroid would alter its mass, form, and moment of momentum. It appears then, that its axis of rotation would be altered, which might account for the fact, that the approximate pole of the oceanic area is not in the equator.

The volcanic surface of the moon, if volcanic it be, would lend considerable support to the view which I maintain, that the water substance emitted by volcanoes is an integral constituent of the fluid substratum. For when the moon broke away from the earth it would carry with it the aqueous constituent of the magma. Owing to the much smaller force of gravity in the moon, the pressure under which this would there be placed would be much less than in the earth. Consequently it would more easily escape, and the signs of volcanic action would be more pronounced. But the difficulties surrounding terrestrial vulcanism are so great, that one is hardly tempted to add the lunar to them.—*O. Fisher, in Nature.*

DR. HUGGINS ON COMETS.

Dr. William Huggins, F.R.S., lately lectured at the Royal Institution on "Comets." He said that in ancient times comets were supposed to presage war, pestilence, and woe, and that as during last year no less than seven comets had been seen, the events of 1881 might in the minds of some seem to give some justification to the idea. The subject of comets was one on which there was no general concensus of opinion even among the masters of science, although of late the spectroscope had done much to give clear knowledge. Some comets, he said, are permanent members of our own solar system; others visit us but once, and will probably never return. When the flight of a comet is more than twenty-six miles per second at the distance from the sun of the orbit of the earth it will go away never to return. A comet leads a humdrum life except when it gets near the sun; then it undergoes violent changes, but at other times it consists of little more than its nucleus. It is probable that the nuclei of some comets contain solid matter, and that the collision of one of these with the earth would have serious effects indeed. By means of the electric light he projected on the screen some magnified drawings of comets as seen through large telescopes, showing that as they neared the sun a kind of cap was thrown out from the nucleus on the one side, from which streamed a long tail on the other. Few photographs of comets had been taken because of their feeble light, the long exposure necessary, and the too great insensitiveness of photographic films; but Dr. Janssen, Dr. Draper of New York, and an astronomer residing near Ealing had taken a few. When they gave sufficient exposure to secure a representation of the tail they lost all the details in the head, and *vice versa*.

Many years ago, when he and the late Professor W. Allen Miller applied the spectroscope to comets, they saw luminous bands like those produced in the spectrum by olefiant gas, and by observing the spectrum of the latter gas simultaneously, and with the same apparatus brought to bear on the light from the comet, their identity was manifest. Most comets gave this spectrum, indicating the presence of some hydrocarbon. But the nucleus of the bright comet of 1881 gave a continuous spectrum, proving beyond doubt the presence of solar rays reflected by cometary matter; the bright lines due to the presence of hydrocarbons were also present, as well as some indications which had been proved by Professor Dewar to invariably accompany the presence of nitrogen. The effects seen in 1881 might have been due to the presence of cyanogen. The light-giving stuff in comets is essentially the same.

Another branch of science, that relating to shooting stars, threw light on the subject. The November meteors go round the sun in rather more than thirty years, and Schiaparelli, of Milan, discovered that they move in the same orbit as the comet of 1861; thus there is a probable identity between the nature of the meteors and the comet. These meteors are very small pieces of matter, which usually ignite by friction and burn away in the earth's atmosphere; at other times some of them come through to the earth. The meteorites which came through contain a long range of chemical constituents, from the iron and nickel, of which some are chiefly composed, to the stony matter of others rich in silicates; some of them contain carbon, hydrogen, and nitrogen. Probably the light of comets is not due to chemical decomposition, but to the setting free of the gases previously occluded in the metals. Dr. Odling, he said, once at the Royal Institution lit up the theater with hydrogen brought down from interstellar space by a meteorite; he (Dr. Huggins) did not intend to attempt anything so sensational, but he might state that hydrocarbons, carbonic oxide, and nitrogen had been obtained from meteorites of both the metallic and stony type.

So far he had been walking on solid ground; beyond, all was speculation in relation to comets. The primary disturbing cause in comets is the action of the sun, and Mr. Crookes thinks that in high vacua the loss of the sun's heat by radiation is very small; so that there may be considerable heat in comets. Professor Tait, of Edinburgh, thinks that the luminous phenomena of the nuclei of comets may be due to stones knocking against each other. He (Dr. Huggins) thought that, in such case, a more complete spectrum would be given, showing the composition of the ignited substances. A feeling is growing among physicists, especially in America, that the light of comets may be due to electrical conditions; but in this direction speculation should advance cautiously, because at present it is supported by no known facts. Professor Zöllner says that, if certain data be granted, the action of electricity is sufficient to explain the phenomena of comets.

DIFFUSION OF SOLIDS.

By A. Colson.

If disks of iron, already partially carbureted, are heated along with fresh disks, both absorb the same quantity of carbon if the diffusion of carbon in the metal is proportional to the duration of the heating. To a given temperature there corresponds a constant coefficient of diffusion of carbon in the iron. This law is only true when the iron is converted into steel; when cast iron begins to be formed, that is a little before the iron becomes brittle, the absorption of carbon decreases. Silica ranks among the bodies most easily diffusible in carbon. By heating platinum in lampblack containing sixty per cent. of precipitated silica, we obtain a crystalline body, Si_2Pt_3, of the specific gravity 14·1, and melting at about the same temperature as common glass.

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